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"Nec aranearum sane textus ideo melior quia ex se fila gignunt, nec noster vilior quia ex alienis libamus ut apes." JUST. LIPS. *Monit. Polit.* lib. i. cap. 1.

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TABLE OF CONTENTS.

NUMBER XXXI.—JANUARY.

NUMBER XXXII.—FEBRUARY.

NUMBER XXXIII.—MARCH.

NUMBER XXXIV.—APRIL.

NUMBER XXXV.—MAY.

NUMBER XXXVI.—JUNE.

PLATES.

ERRATUM.

Page 88, line 20, and page 89, lines 8 and 12, *for* sec-chd *read* sup-chd [supplemental chord].

THE

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PHILOSOPHICAL MAGAZINE

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JOURNAL OF SCIENCE.

[THIRD SERIES.]

JANUARY 1835.

I. *On the Dimorphism of Baryto-calcite.* *By* James F. W. Johnston, *Esq., M.A., F.R.S.Ed., F.G.S., &c., Reader in Chemistry and Mineralogy in the University of Durham.**

THE substance first examined crystallographically and described as a new mineral species by Mr. Brooke, under the name of Baryto-calcite, is now well known to mineralogists, and is to be met with in most cabinets. It has a specific gravity of 3°·66, according to Mr. Children, and its form, by the measurements of Mr. Brooke, is an oblique rhombic prism M on M = 106° 54′, M on P 102° 54′.

Since the discovery of the principle of dimorphism, more particularly since the analysis of the plumbo-calcite enabled me to class the carbonate of lead with that of lime as *isodimorphous* bodies, I have looked to this mineral with very considerable interest. If lime, barytes, strontian, and protoxide of lead constitute an isomorphous group, of which two are already observed to be *di*morphous, we may naturally look for a similar property in the other two; we may expect the carbonates, for example, of barytes and strontian, either in their pure state, or in combination with another carbonate belonging to the same group, to crystallize in two *or more* incompatible forms. But the baryto-calcite measured by Mr. Brooke gave us none of that information we expected from it. The crystalline form was neither that of the carbonate of barytes in its usual form, nor that of the carbonate of lime in calc spar; it was neither a rhomboid nor a right rhombic

* Communicated by the Author.

prism, and yet it bears an analogy to both. It had the oblique character of the one form and the prismatic of the other: it belongs to the hemiprismatic system of Mohs.

Since it was first examined and described by Brooke and Children, the baryto-calcite has been found in considerable quantity in several lead-mines in Alston Moor. More recently, however, it has also been met with in other localities; but apparently under different circumstances, and presenting a different appearance. The lead-mine of Fallowfield near Hexham, in Northumberland, is known to modern collectors of minerals as the locality where the finest specimens of crystallized carbonate of barytes have yet been obtained. In this mine a mineral has for some time been met with, crystallized in six-sided pyramids, pure white, often transparent, having occasionally a beautiful pink tinge, and sometimes opake, from an incrustation, apparently of sulphate of barytes. More lately the same mineral has been met with in one of the lead-mines near Alston Moor, presenting the same characters, with the exception of the pink tinge, which I have not observed in any of the specimens I have seen from that locality.

These crystals scratch carbonate of barytes and the oblique rhombic baryto-calcite of Brooke; have a specific gravity of 3·76 at 60° Fah., and exhibit the right prismatic form of arragonite and carbonate of barytes. The observation as to the form, which in the present case is the most important property, has been confirmed by the examination of Professor Miller of Cambridge.

Another variety of the same mineral, found at Fallowfield, has a pale cream colour and pearly lustre, and forms sometimes masses, more frequently round flattish concretions of the size of a pea and upwards. Viewed through a microscope, these concretions present an aggregation of minute triangular faces, being sides of hexagonal pyramids, similar to those which in the more regularly crystallized specimens sometimes attain nearly half an inch in length. I have analysed both these varieties, and found them to consist of the carbonates of lime and barytes united atom to atom —$(\ddot{C}+\dot{C}a)+(\ddot{C}+\dot{B}a)$— with scarcely a trace of iron and manganese. These crystals have, therefore, the same composition as the oblique rhombic baryto-calcite of Mr. Brooke as determined by Mr. Children. They are, however, of a different form, being right rhombic prisms, and belonging to the proper prismatic system of Mohs, while the oblique rhombic crystals belong to the hemiprismatic system. This mineral, therefore, is dimorphous.

There is, however, a peculiarity in the dimorphism of this mineral which has not, I believe, been observed in any other

instance. The ordinary form of the carbonate of barytes is the right rhombic prism. The carbonate of lime in arragonite crystallizes in the same form; there is nothing very unexpected, therefore, in a combination of the two assuming the same form. Neither will it be very unexpected when we meet, as we probably hereafter shall, with a similar compound of the two carbonates in the form of the rhomboid in which calc spar ordinarily crystallizes. It will be an interesting fact when observed, but we are in some measure prepared for it by the knowledge of the form and composition of the *plumbo-calcite.* But what is remarkable in the second form of the baryto-calcite is, that it is neither a rhomboid nor a right rhombic prism, though, as I have already stated, it partakes of the characters of both.

It is well known that the carbonates of lime, iron, manganese, and zinc are only *plesio*morphous, the oblique angles of their respective rhomboids being 105° 5′—107°—107° 20′, and 107° 40′. Now, the rhombic base of Mr. Brooke's baryto-calcite is 106° 54′; it is considerably within the limits, therefore, of the dimensions which these carbonates assume. Is it unlikely that this rhombic base, approaching so nearly to that of rhomboidal carbonate of lime, should be directly derived from it?

There are two ways in which we may suppose this oblique rhombic form to arise, or two principles with which we may suppose it to be connected. If we suppose that each of the carbonates is capable of crystallizing *when alone*, in the oblique rhombic prism, then we know three incompatible forms of carbonate of lime and two of carbonate of barytes, and we can understand perfectly why they should crystallize together in this form as we find them in the compound mineral in question. The carbonate of lime also would on this supposition form the connecting link between two isodimorphous groups, being itself *tri*morphous. Thus,

Rhomboid.	*Right Rhombic Prism.*	*Oblique Rhombic Prism.*
$\ddot{C}+\dot{Ca}$ in calc spar.	$\ddot{C}+\dot{Ca}$ in arragonite.	$\ddot{C}+\dot{Ca}$ in oblique baryto-calcite.
$\ddot{C}+\dot{Pb}$ in plumbo-calcite.	$\ddot{C}+\dot{Pb}$ in carbonate of lead.	
$\ddot{C}+\dot{Fe}$ in brown spar.	$\ddot{C}+\dot{Fe}$ in junckerite*.	
	$\ddot{C}+\dot{Ba}$ in witherite.	$\ddot{C}+\dot{Ba}$ in oblique baryto-calcite.

But if we suppose that in the oblique baryto-calcite the carbonate of lime retains its common rhomboidal form, as the dimensions of the crystal would at first sight indicate, and

* For an account of this interesting mineral, see *Ann. de Chimie et de Phys.*, June 1834, p. 198.

that the prismatic form of the witherite has modified it so as to produce a species of hybrid or intermediate form, having the prismatic character with a less degree of obliquity (102° 54′) than the rhomboid, then it would be unnecessary as yet to consider either the witherite as *di*-, or the carbonate of lime as *tri*-morphous. How far such a combination of the forms is possible, I am not prepared at present to investigate; it will probably, however, be from the study of the forms of compound minerals, resulting from the union of simple minerals whose forms are known, that we shall arrive at the first general conclusions in regard to the connexion of the forms of chemical compounds with those of the elements of which they consist.

It is not unworthy of remark, that the right rhombic barytocalcite is harder and heavier than the oblique, a relation similar to that which arragonite bears to the rhomboid of carbonate of lime. If we take the mean specific gravity of calc spar at 2·65, and that of the witherite at 4·3, and multiply each by their atomic weights, and divide the sum of the products by the sum of the weights, we obtain for the specific gravity of a compound of the two, atom to atom, 3·707, rather less than the mineral was found to possess by experiment.

In a letter I have just received from Professor Torrey of New York, he mentions a mineral under the name of barytostrontianite, found in considerable quantity at Kingston, Upper Canada. It is not unlikely that an examination of the forms of this compound mineral might lead to interesting results. Unfortunately, the specimens he sent with the letter have miscarried. Should this meet his eye, he may, perhaps, find an opportunity of transmitting others.

Durham, November 1834.

II. *Of the Structure of Animals. By the Rev.* PATRICK KEITH, *F.L.S. &c.**

THE writer who undertakes to describe the productions of animated nature, whether botanical or zoological, soon finds out the impossibility of examining each individual singly. It would be a labour altogether interminable. But the means of abridging it readily suggests itself; it is that of combining into distinct groups or families all such individuals as are found to exhibit a close resemblance in external form, or in internal constitution, and of designating them under a common appellation. We are led irresistibly to regard them as allied together by nature, and possessed of kindred qualities.

* Read before the Hythe Reading Society March 7, 1833; and communicated by the Author.

This is the generalization that tends so much to the advancement of science, and that has, in fact, been made, in a more or in a less philosophical way, by all physiologists from the earliest times. We have seen how it has been done in botany*; let us see how it has been done in zoology. Some, to cut the matter short, go back to Adam, with the beasts, wild and tame, submissively arranged around him †,—the tiger playing with the kid, and the lion with the lamb,—and find in the first individual of the race of men, the first classifier of animals; others go back merely to the period of the Flood, and regard as the first model of zoological classification the arrangements made by Noah in his immense *menagerie* of the ark ‡; lastly, some are content to begin with Solomon, whom they regard not only as a botanist, because it is said of him that "he spake of trees, from the cedar that is in Lebanon to the hyssop that springeth out of the wall §," but also as a zoologist, because it is but reasonable to suppose that a writer who said so much about plants, must have said something also about animals. But upon grounds equally valid we might prove that Solomon was likewise a mineralogist, because he said very truly, as every mineralogist must know, that "there is a time to cast away stones, and a time to gather stones together ||." It would be a lame and impotent conclusion, we confess, and therefore we do not venture to draw it.

But however this may be, the most ancient model of zoological arrangement now extant is that which has been left us by Aristotle, the celebrated philosopher of Stagira, and father of natural history. It is founded chiefly on external characters, but it makes a pretty near approach, notwithstanding, to the arrangements of nature. Under a primary division into viviparous and oviparous—that is, into such as produce their offspring alive, and such as produce first an egg—animals are distributed, in this arrangement, into four classes,—quadrupeds, birds, fishes, insects. It is somewhat analogous to the botanical arrangement of Theophrastus, borrowed perhaps from his great master, by which he distributes plants into trees, shrubs, undershrubs, and herbs ¶, striking, but popular rather than philosophical. Hence many alterations were introduced into it by succeeding zoologists, as by Pliny, Gesner, Aldrovandus, but particularly by our countryman Ray, till at last the subject was taken up by Linnæus, that great reformer of systems, and brought under the scrutiny of his keen and

[* See Mr. Keith's papers, on the External Structure of Imperfect Plants, and on the Internal Structure of Plants, Lond. and Edinb. Phil. Mag. vol. iv. p. 252, vol. v. p. 112.—Edit.]

† Genesis, ii. 19. ‡ Genesis, vii. 15.

§ 1 Kings, iv. 33. || Eccles., iii. 5.

¶ Περι Φυτων ἱστοριας. το. Α.

penetrating eye. The result was that his arrangements in zoology were adopted and applauded with the same eagerness and universality as his arrangements in botany. He distributes animals into six classes,—mammalia, birds, amphibia, fishes, worms, insects *. It was a great improvement upon preceding arrangements, but still it is liable to many objections. Under the honourable and imposing title of *Primates*,—the nobles of the creation,—it groups together men, monkeys, and bats, in the same class and in the same order; while it exhibits other incongruities equally palpable. But from arrangements founded upon the number of teeth, or of toes, what was to be expected but unnatural associations? It should be recollected, however, that his arrangements are professedly artificial, and are not to be tried by such rules of criticism as are applicable to arrangements professing to be natural. They have been reformed and improved by Blumenbach †, as far, perhaps, as they are capable of improvement; and in their present improved state they may be regarded as making a laudable approximation to the arrangements of nature. The characters of the classes are taken partly from the external structure, and partly from the internal structure. But Cuvier in his *Règne Animal*, and Carus in his Introduction to the Comparative Anatomy of Animals, have established a new principle of arrangement, and have shown to the satisfaction of zoologists, that all characters of classes truly natural must be taken from the internal structure only, as exhibiting most distinctly the several *grades*, or several degrees of excellence, that exist among animals, whether as relative to sensation or to locomotion—the very essence of animality, and measure of animal perfection. This view may be taken in the order, either of the ascending or of the descending scale, according to the peculiar object of the investigator. Carus adopts the first of the two modes, and ascends from the lowest and minutest animalcule up to man. Cuvier adopts the second of the two modes, and descends from man down to the meanest entity endowed with animal life. His leading and primary divisions, now universally [?] adopted, are the four following ‡.

The first and highest division of the animal scale includes man, and the animals resembling him most nearly in the form and complexity of their internal structure. The leading character on which it is founded is, that the brain, and the chief trunk of the nervous system, are inclosed in bony coverings the former in the *cranium*, the latter in the *vertebræ*, or [joints composing the] back-bone, to the sides of which the ribs, and the bones composing the limbs, which are never more than

* *Systema Naturæ*, 1735. † Manual of Nat. Hist., R. T. Gore.
‡ *Règne Animal*, Introd.

four in number, are attached, forming in their *ensemble* the skeleton or carpentry of the body. Animals of this class are said to be vertebrate, *Vertebrata.* They have red blood; a muscular heart; a mouth, the origin of the intestinal canal; two horizontal jaws; distinct organs of sight, smelling, hearing, tasting, situated in the cavities of the head; a generally diffused tact or circumscribed touch; the locomotive muscles attached to bones; the *viscera* lodged in the head and trunk; the head distinct from the body; and the sexes in separate individuals. Of this general model there are many varieties, the descending gradations of which may very easily be traced from man to the meanest reptile.

The second division of the descending animal scale includes the *Mollusca*, namely, individuals which consist of a soft and gelatinous mass, and exhibit a structure less complex than that of the *Vertebrata.* The body is without a skeleton, and without a distinct head; the muscles being attached to the skin, forming a soft and contractile covering, (which in many species is encrusted with a shell), in which envelope the *viscera* are contained, together with the nervous system, which in these animals takes the form of scattered masses of threads. The chief of these masses lies in [or around] the œsophagus, and is called the brain. Of the senses common to the *Vertebrata*, they seem to possess only taste and vision; with the exception of one family—*Sepiæ*—which exhibits also organs of hearing. But they have an apparatus for circulation, respiration, digestion and secretion, scarcely less complicated than that of the preceding division.

The third division of the descending animal scale is that of worms and insects, designated by the appellation of articulated animals, *Articulata*, exhibiting a structure still less complicated [?] than that of the *Mollusca.* Their nervous system consists of two cords, extending along the belly, and expanding at regular intervals into knots, or *ganglia.* The first of these, placed on the œsophagus, is called the brain, though not much larger than the rest. The covering of the body, in some cases soft, in others hard, is divided by transverse folds into a certain number of rings, with the muscles attached to the interior; and hence their appellation of *Articulata*, or, as MacLeay would rather call them, *Annulosa* *. Many of them have lateral and articulated limbs, originating in pairs, while others are wholly destitute of limbs. They have not a real circulation, except, says Kirby, the *Arachnida* and *Annelida* †. They have not lungs, but spiracles. They have organs of

* Linn. Trans., vol. xiv. Part I. [or Phil. Mag. vol. lxii. pp. 192, 255.]
† Introd. to Entomol., vol. iv. p. 80.

taste and of sight, but they have no perceptible or indubitable organs of hearing, with the exception of a single tribe, the *Crustacea*; and the jaws, if any, are lateral.

The fourth and lowest division of the animal scale includes the zoophytes of preceding naturalists, which Cuvier now designates by the appellation of radiate animals, *Radiata.* They exhibit the greatest simplicity of animal structure, and a peculiarity of conformation that cannot be mistaken. In the foregoing divisions, the organs of motion and sensation are found to be symmetrically placed on two respective sides of a certain axis. In the zoophytes [and other *Radiata*,] the corresponding organs are arranged in rays around a common centre, and hence their appellation of radiate *. The subjects of this division approach the homogeneous character of plants. They have no distinct nervous system, nor specific organs of sense, but merely nervous molecules dispersed throughout a gelatinous mass‡. In a few of them, you may trace some faint vestiges of a circulation, with respiratory organs on the surface of the body. In the polypi, the intestines are a mere bag without passage; and in the infusory animalcula, the lowest in the animal scale, the individual is merely a homogeneous mass of pulp, endowed with motion and feeling. With these divisions in view, we proceed to exhibit a brief and popular sketch, first, of the external structure, and secondly, of the internal structure, of animals.

Of the External Structure of Animals.

Division I. The Vertebrata.—Of animals of the division *Vertebrata*, some are viviparous, and furnished with teats by which they are enabled to suckle their young; this is the class of the Mammalia: some are oviparous, and adapted by their structure to the act of flying; this is the class of Birds: some are destined to live in water, and adapted by their structure to the act of swimming; this is the class of Fishes: and some are doomed merely to crawl upon the earth, and to pass a great part of their existence in a state of stupor; this is the class of Reptiles.

Class 1. If an individual of the class Mammalia is taken and surveyed at the period of its perfect development, it will be found to be composed of a head, a neck, a trunk, and limbs. We will take our view of these parts as they occur in man, who stands incontrovertibly without a rival at the head of the

[* It has been shown by Dr. Agassiz, in a paper in our last volume, p. 369, that there is a bilateral symmetry even in certain *Radiata*, notwithstanding their radiant structure.—Edit.]

[† Mr. Keith seems here to confound the organization of all the *Radiata* with that of one of the groups referred to them by Cuvier: in the Starfish and Echini, for example, there is a distinct radiant nervous system.—Edit.]

animal creation, not merely as the first in the first rank, but as constituting an order of himself, into which no other genus is worthy of being admitted, and as exhibiting a fabric that we cannot but regard as the most perfect model of animal organization.

In surveying this model, the first thing that arrests our attention is that most remarkable and striking peculiarity connected with, and dependent upon, structure, by which man is at one glance distinguished from all other animals whatever, and elevated, as it were, on an eminence which they can never attain, namely, that of his upright or erect posture, through means of which, while other animals look prone upon the ground, we raise our face to heaven, to contemplate the throne of God. Ovid, the sweetest of Latin poets, has described this distinguishing attribute of man in language peculiarly felicitous:

> Pronaque cum spectant animalia cætera terram
> Os homini sublime dedit, cœlumque tueri
> Jussit, et erectos ad sidera tollere vultus.—*Metam.* i.

Milton also, the loftiest and most sublime of British bards, whose epic rank and dignity is second only to that of Homer and of Virgil, has been equally felicitous with Ovid in his description of the dignity of the human form:

> Two of far nobler shape, erect and tall,
> God-like erect, with native honour crowned,
> In naked majesty, seemed lords of all.
> *Paradise Lost,* book iv.

Of this noble and dignified structure, the portion that claims our first notice is the head, the capital that crowns the fabric. Its elevated position; its ample expansion of countenance,—the index of the operations of mind; its rounded and globular form; its comely covering of hair, hanging in the unadorned simplicity of nature, or modified by the contrivances of art; and its serving as the seat of almost all the organs of sense; are prerogatives that entitle it to our peculiar consideration.

If we look at its elevated position, we shall find that the head assumes, as it were, the post of honour, being placed above all the other portions of the fabric, and hence giving the necessary elevation to the organs with which it is furnished, particularly to the organs of vision, by which we can thus command a wider and more extended view of the glories of external nature. Had man been destined to walk or to stand on all-fours, as some philosophers have presumed that he originally was, he would have been in a worse predicament than even any of the quadrupeds, whose look, though prone,

is still well adapted to their form and condition; for in that case his face would have been depressed to a parallel with, or even to an angle beyond, the level of the horizon, and his look turned neither forwards nor backwards, nor to the one side, but directly downwards. It could not then have been said that he was made to contemplate the heavens. But the inequality that is so notoriously evident in the length of our legs and arms, together with their mode of articulation and flexure, affords proof sufficient that nature never intended man either to walk or stand except upon his feet only, and that, partly at least, for the purpose of giving elevation to the head.

If we look at its expansion of countenance, we shall find that the head most nobly vindicates its preeminence over all the other portions of the human fabric, and conspicuously exalts the dignity of man. The amplitude of the forehead; the expression of the eyebrow; the fire and brilliancy of the eye; the bold and manly, or the delicate and feminine, profile of the nose; the blush and dimple of the cheek; the witchery of the smile; and the lovely contour of the chin; are attributes of man's countenance that are palpable to every one, and are the perpetual theme of the admiration, whether of the lover or of the philosopher. To this we ought also to add that interminable diversity of feature and of lineament so remarkable in the human face, that out of the countless millions of mankind possessing all that closeness of resemblance and all that striking similitude of form that are necessary to determine the species, or even the variety, no two individuals have ever yet been found so exactly alike as to make it a matter of any great difficulty to distinguish the one from the other.

Philosophers reduce the peculiar traits of countenance that characterize the several races of mankind to certain manifest varieties, of which the following are the most important: 1st, The Caucasian, whence the European variety: countenance oval; features delicately blended; forehead high and broad; nose aquiline; cheek-bones not prominent; complexion fair. 2nd, The Mongolian variety: face broad and flat; nose flat; space between the eyes wide; chin prominent; complexion olive. 3rd, The American variety: visage broad, but not flat; cheek-bones prominent; forehead short; eyes deeply fixed; nose flattish, but prominent; countenance red or of a copper tint. 4th, The Negro variety: face narrow, projecting in the lower part; forehead narrow, retreating, arched; eyes prominent; nose and lips thick; complexion black. 5th, The Malay variety: face not so narrow as in the Negro, projecting downwards; nose bottled; mouth large; complexion tawny*.

* Blumenbach's *Phys.*, by Elliotson, p. 391.

If we look at its rounded and globular form, we shall perceive that the human head has a grace and beauty conferred upon it that do not belong to any other form peculiar to any other animal; and even in man, the varieties having most of the globular form have the most of beauty. This will appear very plainly, if the investigator will take the trouble to compare the form of the Caucasian variety with that of the other four varieties, either in the actual *crania* of dissected subjects, if he has access to such, or in the drawings with which anatomists have furnished us. The head of the Georgian female is regarded, by Europeans at least, as the most perfect model of human beauty. It is the most globular of all the varieties, and is generally quoted as an example of the most exquisite of capital forms. In the other varieties, but particularly in that of the Negro, the forehead is so much flattened, and the lower part of the face—the mouth and jaws—so much protruded, as to suggest the degrading idea of a snout or muzzle; lowering, in our estimation, excessively, the pretensions of the Negro head, whether to grace or to beauty. Physiologists have even instituted a standard of perfection with regard to the form of the head, which they find in the facial angle of the Caucasian variety. Viewing the head in profile, when the body stands erect, draw a line from the greatest projection of the forehead to the upper maxillary bone: this is the facial line. From beneath the basis of the nostrils, draw a horizontal line meeting the facial line: this junction gives the facial angle *, and the measure of the relative projection of the jaws and forehead. The nearer it approaches to a right angle, or in other words, the less prominent the jaw, the more perfect is the form, and the greater the presumed sagacity of the individual. But if the head of the Negro will not bear a comparison with that of the Caucasian, much less will the head of any of the inferior animals bear it.

If we look at its comely covering of hair, we shall find in that feature also another source of beauty. Among Europeans, Eastern Asiatics, and Northern Africans, the hair of the head grows to a great length, particularly in females. We have known it to exceed the length of three feet †. Its colour is black, brown, or red, according to climate, or to other contingencies. On the fore part of the head it falls towards the brow, on the back part towards the neck, and on the sides towards the shoulders. It is very ornamental, and admits of

* Blumenbach, by Elliotson, p. 388.

[† Authentic cases, we believe, are upon record, in which the hair had attained a much greater length.—Edit.]

being done up in a great variety of ways, so as to please all tastes and all fancies :—

> Cui *flavam* religas *comam,*
> Simplex munditiis?—Hor., lib. i. ode v.

Yet sometimes crops are the fashion, and sometimes wigs; but nobody chooses a red wig, as I believe. There seems, indeed, to be a prejudice against red hair in any shape whatever. It is alleged, but how truly I cannot say, to have some intimate connexion with the temperament of the body, causing a fetid and disagreeable odour. In man, black hair is supposed to be expressive of strength; in woman, of vivacity: whilst in woman, the *blond* is thought to be expressive of delicacy, and in man, of I know not what, that is devoted to pleasure. So says Bichât*. The beard is peculiar to males. Christians shave it; Jews suffer it to grow. It appears at the age of puberty, of which it is a sign. It is shorter than the hair of the head, as well as more given to curl, and its colour is generally either black or red.

Lastly, if we regard the head as being the seat of the organs of sense, we shall find its preeminence above all the other parts of the human fabric to be most signally demonstrated. First, as containing the eye, the organ of vision, which, stationed like the sentinel in his watch-tower, surveys from its lofty height the objects placed around it, and unfolds to the individual the beauties of the external world. Cicero seems to have been duly impressed with a conviction of this truth when he wrote the following sentence: "*Nam occuli tanquam speculatores, altissimum locum obtinent, ex quo plurima conspicientes, funguntur suo munere*†;"—'For thus the eyes, placed like sentinels on a watch-tower, discharge their function with an extended sphere of vision.' Secondly, as containing the ear, the organ of hearing, calculated to receive the impressions of sound, to give us notice of the approach of external objects, and to enable us to appreciate the value of tones, whether they be the modulations of music, or the articulations of a spoken language. Thirdly, as containing the nose, the organ of smell, and source of balmy delights, projecting, as Haller observes, "like an engine in the air‡," to arrest and collect the perfumes, sweets, and odours that are exhaled from the treasures of Flora, and wafted on the winds. Fourthly, as containing the tongue, the organ of taste, and with the mouth the arbiter of savours, discriminating between the clean and the unclean, the noxious and the wholesome, the produc-

* *Anat. Gen. Syst. Dermoid.* † *De Nat. Deor.*

‡ First Lines, by Cullen, sect. 465.

tion that is good for food and the production that is to be rejected; as well as forming a principal part of the apparatus of speech, the distinguishing attribute of man. Fifthly, as possessing in common with all the rest of the surface of the fabric the general attribute of tact, which exists, however, in the highest degree only in the palms of the hands and at the ends of the fingers, and is there denominated touch. Finally, besides being the seat of the organs of sense, it is also the seat of the endowment of intellect, as is indicated by our own internal convictions, leading us irresistibly to the conclusion that thought has its residence in the head. The head thinks.

The second portion of the fabric of the human body is the neck, which we may regard as the shaft or column that supports the grand and Corinthian capital of the head, in the base of which it originates. In man it assumes a circular and columnar form, possessing great natural grace and beauty. Anacreon exhibits a fine idea of its fascination in his directions to the artist who was about to take the portrait of his female friend:

> Τρυφερȣ̃ δ' ἔσω γενεἰȣ
> Περὶ λυγδίνῳ τραχήλῳ
> Χάριτες πέτοιντο πᾶσαι.—Ode xxviii.

'Under her beautiful chin, around her *snowy* neck, let all the Graces be fluttering.' The description was no doubt suggested by the original from which he drew. But, in addition to its native loveliness, the neck admits also of such artificial ornaments as may be suggested by the fertile fancy of the arbitresses of female fashion. "Thy cheeks are comely with rows of jewels; thy *neck* with chains of gold *." So said the wisest of men. It possesses, besides, a peculiar flexibility, by which the movements of the head are multiplied and facilitated extremely, as well as rendered peculiarly elegant and expressive. Tapering delicately towards the middle, it begins again to expand, till it ultimately rests upon the shoulders, and forms the connecting link between the head and the trunk. In quadrupeds, though it does not always assume the circular form, still it possesses much beauty, as in the case of the horse. "Hast thou given the horse strength; hast thou clothed his *neck* with thunder †?"

The third portion of the fabric is the trunk, which we may regard as the base or pedestal that gives bulk and stability to the individual, with support and attachment to the neck and head, as well as to the several limbs. It is divided superficially into certain peculiar regions,—the back, the sides, the shoulders, the breast, the abdomen. The greatest bulk of cir-

* Canticles, i. 10. † Job, xxxix. 19.

cumference of the body lies within a line encircling the breast; but in a high state of corpulency, or *embonpoint*, the greatest circumference may lie within a line encircling the abdomen, as in the case of Falstaff's waist, according to Shakspeare:

"*Fal.* My honest lads, I will tell you what I am about.

"*Pist.* Two yards and more.

"*Fal.* No quips now, Pistol; indeed I am in the *waist* two yards about, but I am now about no *waste.* I am about thrift *."—A rare thing for Falstaff to be about, and worthy of special notice!

In the body, as also in the head and neck, you may readily trace a medial line, having similar parts or organs on each side, on the right and on the left,—the two eyes, the two nostrils, the two ears, the two shoulders, the two breasts, the two sides. The medial line of the trunk is displayed most conspicuously in the back, following the course of the backbone, and in most of the Mammalia terminating in a tail, of which men and some monkeys are destitute. In men the surface is covered with a naked skin, which gives the body a quick and susceptible tact throughout, but requires the aid of clothing.

The fourth and last portion of the fabric is that of the limbs. In the Mammalia, and indeed in all vertebrate animals, where limbs are present, they are almost always four in number; and upon the principle of duality, and of a right and left side, which we have just recognised, they go in pairs,—two fore limbs, and two hind limbs. In man the two fore limbs are composed of the arms, the fore arms, and the hands. The arms extend from the shoulder to the elbow, the fore arms from the elbow to the wrist, and the hands from the wrist to the tips of the fingers. Each hand is composed of a *metacarpus*, or body, which constitutes what we call the back and hollow of the hand, together with four fingers and a thumb, the thumb being so placed as to stand in opposition to the fingers, and thus greatly to facilitate the grasping or holding of small bodies. The palms of the hands, and particularly the ends of the fingers, are the peculiar seat of touch; to which the nail, placed only on the one side of the extremity, affords a kind of support. No other animal possesses an organ of touch so perfect as that of man. The hand of apes makes the nearest approach to it, but is far from reaching to its perfection of form. Even the hand of the ourang-outang, the most perfect of apes, is too long in proportion to its width, and the thumb, which scarcely reaches to the root-joint of the fore finger †, too short, and too

* Merry Wives of Windsor, Act I. Sc. 3.

† Dr. Abel. Griffith's Suppl. Hist. of Man. [On the hand of the ourang-outang, see also Dr. Jeffries's paper in Phil. Mag. vol. lxvii. p. 183, 188. —Edit.]

inefficient, and too little suited to be put in opposition to the fingers, to bear a comparison with that of man. The two hinder limbs are composed of the thighs, the legs, and the feet. The thighs extend from the hip to the knee, the legs from the knee to the ancle, and the feet from the ancle to the tips of the toes. Each foot is composed of a *metatarsus*, or body, constituting what we call the back and sole of the foot, which terminates in five toes,—the great toe, the little toe, and the three middle toes,—all placed upon the same level, so that the great toe cannot be opposed to the other toes, as the thumb is opposed to the fingers of the hand; a conformation evidently in keeping with the erect posture proper to man, as being calculated to enable him to stand or to walk firmly on the soles of his feet, and to leave his hands and arms at liberty; whereas the hinder limbs of apes may be said to end in hands rather than in feet, and to have palms and prehensile fingers rather than soles and toes, which, when placed upon the ground, rest, not on a broad and flat surface, like the sole of the human foot, but merely on the exterior edge of the organ, and hence present no proper basis of support to uphold the fabric in an upright position. Thus man is the only two-handed animal that exists; for apes are in fact four-handed, as the foregoing detail exhibits them, and are hence duly entitled to the epithet *Quadrumana**, by which they are now designated, and by which the difficulty that puzzled Linnæus has been at length overcome: "*Nullam characterem hactenus eruere potui, unde Homo a Simia internoscatur*†;"—'I have hitherto been able to discover no mark by which men may be distinguished from monkeys.'

If other proofs were wanting to show the superiority of men to monkeys, it would be easy to adduce them. They are destitute of speech; they are destitute of intellect. What is this owing to? Camper, who dissected an ourang-outang, found in the front part of the neck two bags, or cavities, communicating with the *trachea*, which seemed to him to be incompatible with distinct articulation‡. After all, it is doubtful whether the bags in question form an absolute bar to speech. Mr. Lawrence thinks they do not, and regards the total incapability of apes to generalize their ideas, or to pursue a consecutive train of thought, as being the only true bar that lies between them and speech. Thus the grand cause of their inability to form a spoken or articulate language is placed beyond the reach of anatomical detection, and is apparently owing to their want of intellect. Sir Charles Bell regards their inability to

* Cuvier, *Règne Anim., Mammal.* † Quoted by Blumenbach.

‡ Griffith's Suppl. Hist. of Man, i. 235. [See also Dr. Jeffries's paper, *ubi sup.*, p. 184, 185.—Edit.]

articulate as resulting not merely from want of intellect, but from want of due organization also*, or of the due complement of nerves necessary to associate the several organs in one act of vocality. Why they are destitute of intellect, though furnished with an organization approaching to that of man, it is not our present business to inquire; but facts show that they are so. How, else, are they so totally incapable of education? The ourang-outang and chimpansé have even been admitted into human society, by way of experiment, but they have shown no disposition to adopt the habits and manners of men; and though capable of imitation in some things, they can never be taught to imitate the articulate tones of the human voice. Besides, they have no relish for the society of men; and remain, even in the midst of mirth, "for ever silent and for ever sad." Hence, though we may fairly say of them, "*Mens agitat molem* †," yet we cannot say that it is the "*mens divinior*" which is proper to man.

In quadrupeds the feet are four in number, as the name imports. They are single and undivided, as in the horse; or they are divided into toes, of which some genera have two, as the ox and goat; and some more than two, as the hog and elephant, which last has five fingers inclosed within the skin of the foot; while others have the toes united by means of an intervening membrane, and have hence obtained the appellation of web-footed, as in the case of the seal and otter. Yet the limbs of quadrupeds, upon the whole, whether anterior or posterior, will be found to exhibit a striking analogy to the type of man, if we look at and compare the same joints.

[To be continued.]

III. *An Abstract of the essential Principles of* M. Cauchy's *View of the Undulatory Theory, leading to an Explanation of the Dispersion of Light; with Remarks. By the Rev.* Baden Powell, *M.A., F.R.S., Savilian Professor of Geometry, Oxford.*‡

SINCE the appearance of a notice in one of the late Numbers of this Journal §, referring to the subject above named, several circumstances have led me to adopt a different plan from that therein proposed, relative to a publication on the subject. The question of the dispersion has been somewhat more canvassed of late; and at the Edinburgh Meeting of the British Association for the Advancement of Science, some suggestions which have been lately made led me to offer a few remarks bearing upon an important distinction which must

* Bell on the Human Hand, p. 216. † Virgil's Æneid, vi. 727.

‡ Communicated by the Author.

§ Lond. and Edinb. Phil. Mag., vol. iv. p. 396.

be introduced. The nature of any such distinction cannot be made intelligible without some previous statement or explanation of the theory referred to: to supply such a statement will be my object in the ensuing pages. And I am the more desirous to do this, because, I believe, the elaborate researches of M. Cauchy are even yet but little known to British students. He has directed his profound analytical skill to the construction of a theory of undulations built on such an hypothesis of the arrangement and mutual action of a system of molecules as leads to results including the general theoretical explanation of the unequal refrangibility.

The slowness with which a knowledge of the labours of Continental philosophers too commonly finds its way into England, has been singularly evinced in several instances, but more especially in optical science; and in the present case, partly, perhaps, from the particular form in which these researches have been successively given to the world, and partly from an appearance of abstruseness and difficulty in the subject, they do not seem to have become known among us as from their high interest, importance, and elegance they deserve to be. The first notice of them which appeared in this country was, I believe, that contained in Sir David Brewster's Report on Optics, read at the meeting of the British Association at Oxford, 1832; and even this was two years after the publication of the last part of these researches in France.

In the following short abstract I shall endeavour to put the leading points of M. Cauchy's investigations in as connected and simplified a point of view as the nature of the case will admit. This may, I trust, render the subject more generally accessible, and tend to remove some of its apparent abstruseness and difficulty. The abstract mathematical part of the inquiry is of considerable extent; but as the object of the present paper is confined to tracing it so far as to include the theory of dispersion, it will be found susceptible of abridgement.

I shall abstain at present from all remarks on the physical application of the theory, which it will form an important object to refer to in the sequel; and before entering upon the principles of the theory, I will briefly state the original sources, to which those inquirers who wish to examine the subject in all its detail will of course refer.

The particular researches which we are about to examine are closely connected with various others, of the same author.

M. Cauchy, in the third volume of his *Exercices de Mathématiques* (1828), liv. xxx. xxxi. p. 188, has given an elaborate memoir, entitled "Sur l'équilibre et le mouvement d'un système

de points matériels sollicités par des forces d'attraction ou de répulsion mutuelle." In this paper he considers the subject in a very general point of view. He supposes a great number of molecules or material points arbitrarily distributed in space, and subject to the influence of mutual attractive or repulsive forces tending to put them in motion. He assumes these forces to be proportional to the masses and some function of the distance between any two molecules; and hence proceeds to deduce expressions which give rise to certain partial differential equations representing the motions of the molecules under the above conditions, referred to three rectangular axes. The investigation pursued is of a high degree of generality; and expresses the equilibrium or motion of such a system of particles. It is also closely connected with another inquiry, which he has discussed in a separate memoir,—the interior equilibrium or motion of a solid body, considered as a system of distinct molecules.

In the fourth volume (1829) of the same collection, p. 129, liv. xlii., the author enters upon some further applications in a memoir, entitled "Sur les équations differentielles d'équilibre ou de mouvement pour un système de points matériels sollicités par des forces d'attraction ou de répulsion mutuelle." This investigation, relating chiefly to the "elasticity" of such a system, turns upon the equations of motion deduced from those in the former memoir, when simplified by certain conditions, which reduces them to a less general character; but which suffices for the object immediately in view. More precisely, the author has shown, that those equations of the former memoir which include a great number of coefficients dependent on the nature of the system, reduce themselves, in the case in which the elasticity is the same in every direction, to other formulas, including only a single coefficient: these, in fact, coincide with expressions before obtained by the investigations of M. Navier. In these equations given in the fourth volume, the coefficients in question having disappeared, and the masses of the molecules being supposed equal, two and two, and distributed symmetrically on each side of a given point, on straight lines passing through that point, the subject is much simplified. In a subsequent article the author proposes to show how the general integrals of these equations may be deduced, with a view to establishing the laws of the propagation of *sound* in a solid body.

But for the investigation of the theory of light, at least when regarded as homogeneous, a more simple view of the above analysis will suffice. It is not, as the author observes, at all necessary to have recourse to these general forms of in-

tegration; but it will suffice, among the different motions which the system may receive, to consider those in which the displacements remain the same for all the molecules situated in a plane parallel to a given plane; and in the investigation of phænomena which are restricted to the conditions of this sort of motion, we shall find that simpler differential equations may be substituted for those above referred to. The deduction of these equations, and the establishment of a general mathematical theory of such *vibrations* of molecules of an elastic medium as shall account for the phænomena of *homogeneous* light, form the subject of another memoir in the fifth volume, commencing at p. 19, and extending through the remainder of the forty-ninth, the fiftieth and fifty-first livraisons of the same work, published in 1830.

The investigation is left apparently incomplete in the fifty-first number, and it does not appear that any continuation of the series has since been printed.

In 1830, however, M. Cauchy published a separate tract, entitled "Mémoire sur la dispersion de la lumière," in which, after referring to the investigations contained in his former memoirs, in which the propagation and polarization of light are explained, he observes that the fundamental expressions are only approximate. Those differential equations which are employed in the fourth volume for deducing the theory of waves (as we have already observed), are derived from others, yet more general, in the third. These equations, however, suffice for the laws of homogeneous light. But it struck the author's friend, M. Coriolis, that possibly some of the terms which had been neglected in the approximation might include what was necessary for extending the theory to light of different refrangibility; or, in other words, for overcoming the greatest and indeed only formidable objection which has hitherto stood in the way of the complete application of this theory. M. Cauchy on examination found this idea fully verified, and has proceeded in this memoir to give the complete investigation of it.

He takes up the subject from its first principles, and deduces the fundamental equations of motion, which (with a slight difference of form) are the same as those established in his third volume. He thence proceeds, without adopting the same simplifications as those before used, to the integration of these expressions. In the course of this process he arrives at the same conclusions before established respecting the propagation of plane waves, and further develops those conditions by which the relation between the length of the undu-

lation and the time is established, at least in a general and theoretical point of view.

Lastly, in the *Mémoires* of the Academy of Sciences, tom. x. 1831, p. 293, there is a paper by the same author, entitled "Mémoire sur la théorie de la lumière," read to the Academy 31st May 1830. This contains a more full exposition of the physical application of the theory of waves to the various phænomena, especially those of polarized light; and exhibits its accordance with the experimental laws of Brewster and Arago, and with the formulæ of Fresnel.

Preliminary Property of Surfaces of the second degree.

It may be convenient here to premise a brief statement of some points in the general investigation of surfaces of the second degree, which is given by M. Cauchy in the third volume of his *Exercices de Mathématiques*, liv. 25, and of which important use is made in the theory of waves.

Assuming, in the first instance, the equation of the second degree with three variables in its most general form, the author deduces the equations of diametral planes, and shows what conditions give them perpendicular to each other, or principal planes; and whether they all three intersect in one point, or whether their intersections lie in a given line, such line being called a central line, and such a point the centre. In this last case the lines of their intersections are the principal diameters or geometrical axes of the surface.

The centre being taken as the origin, the equation is

$$\mathrm{L}x^2+\mathrm{M}y^2+\mathrm{N}z^2+2\mathrm{P}yz+2\mathrm{Q}zx+2\mathrm{R}xy = 1 ;$$

and if a straight line passing through the origin be inclined to the three axes at angles α, β, γ, its equations being

$$\frac{x}{\cos\alpha} = \frac{y}{\cos\beta} = \frac{z}{\cos\gamma}:$$

whence likewise we have

$$\cos^2\alpha+\cos^2\beta+\cos^2\gamma = 1.$$

If also we have the three following values equal,

$$\frac{\mathrm{L}\cos\alpha+\mathrm{R}\cos\beta+\mathrm{Q}\cos\gamma}{\cos\alpha},$$

$$= \frac{\mathrm{R}\cos\alpha+\mathrm{M}\cos\beta+\mathrm{P}\cos\gamma}{\cos\beta}$$

$$= \frac{\mathrm{Q}\cos\alpha+\mathrm{P}\cos\beta+\mathrm{N}\cos\gamma}{\cos\gamma}$$

which we will write for brevity $= s^2$, then from these equations, by an easy process, on eliminating the angles, we can deduce an equation of the third degree with respect to s^2,

$$(L-s^2)(M-s^2)(N-s^2)-P^2(L-s^2)-Q^2(M-s^2)-R^2(N-s^2) \\ +2PQR = 0.$$

It follows that each of the three real roots of this equation has corresponding to it a distinct set of values of the cosines of α, β, γ, and consequently a distinct straight line passing through the centre determined as above: it is also shown that this equation has always three real roots.

Also, (supposing the three roots *unequal*,) it is proved that the three lines will be *at right angles* to each other, and will *coincide in position with the three geometrical axes of the surface* represented by the equation at first assumed.

If two, or all three, roots are *equal*, the author considers the corresponding cases, in which two or all three of the lines passing through the origin are indeterminate in position. But in the former case the two, though arbitrarily placed in other respects, yet lie in one plane, to which the third is perpendicular: in the second case, they are any three lines arbitrarily drawn through the origin; and we are consequently at liberty to assume them so as to be perpendicular to each other.

When the surface is an ellipsoid the three values of s^2 are precisely the squares of the three semiaxes.

Equations of Motion of a System of Molecules.

Let us conceive a system of material molecules arbitrarily distributed in space, and subject to be put in motion by the force of their mutual attractions or repulsions. We will call the mass of one of these molecules m, and those of the others m, m', m'', &c.

Let us first suppose the system in a state of equilibrium. Referring to three coordinate axes, let us suppose the coordinates of m to be $\quad x \quad y \quad z;$

of m, $\quad x+\Delta x \quad y+\Delta y \quad z+\Delta z;$

the distance of m from m to be r: whose projections on the three coordinate planes are Δx, Δy, Δz; whence, on the principles of solid geometry, we have

$$r^2 = \Delta x^2 + \Delta y^2 + \Delta z^2 \qquad (1.)$$

and supposing α, β, γ to be the angles which r forms with the positive semiaxes, we have also

$$\frac{\Delta x}{r} = \cos\alpha \quad \frac{\Delta y}{r} = \cos\beta \quad \frac{\Delta z}{r} = \cos\gamma \qquad (2.)$$

Now, with regard to the attractive or repulsive forces, let us suppose them to be proportional to the masses of the molecules, and to some function of the distance $f(r)$, which is positive in the case of attraction and negative in that of repulsion; the mutual attraction of m m will then be expressed by

$$\mathrm{m}\, m\, f(r) \qquad (3.)$$

Then, (using the symbol S to represent the sum of a series of corresponding terms referring to the molecules m, m', m'', &c.) the resultant of the attractions or repulsions of the other molecules upon m will have for its projections

$$\mathrm{m}\, S[m \cos\alpha\, f(r)],\ \mathrm{m}\, S[m \cos\beta\, f(r)],\ \mathrm{m}\, S[m \cos\gamma\, f(r)] \quad (4.)$$

and when the whole is in equilibrium, we shall consequently have

$$S[m \cos\alpha\, f(r)] = 0,\quad S[m \cos\beta\, f(r)] = 0,$$
$$S[m \cos\gamma\, f(r)] = 0 \qquad (5.)$$

Let us now suppose the equilibrium destroyed, and a motion to commence such, that the distance of the molecules m m, shall vary in a ratio little different from unity. And at the end of a time t, let the small displacements be ξ, η, ζ, respectively parallel to the axes, and functions of x, y, z, t, whilst the small displacement in the distance r is ε.

Thus we shall have a new set of values, corresponding to each of the former expressions: we shall find the new coordinates of m, $\quad x+\xi \qquad y+\eta \qquad z+\zeta$

those of m, $x+\xi+\Delta(x+\xi)$, $y+\eta+\Delta(y+\eta)$, $z+\zeta+\Delta(z+\zeta)$

whilst for r, we have $\quad r(1+\varepsilon)$

and its projections $\quad \Delta x+\Delta\xi, \quad \Delta y+\Delta\eta, \quad \Delta z+\Delta\zeta$

and (substituting from (2.) the values of Δx, &c.)

$$r^2(1+\varepsilon)^2 = (r\cos\alpha+\Delta\xi)^2+(r\cos\beta+\Delta\eta)^2$$
$$+(r\cos\gamma+\Delta\zeta)^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6.)$$

Again, the cosines of the angles which the line joining m m forms with the axes, will no longer have the values (2.), but at the end of the time t will be represented by

$$\frac{\Delta x+\Delta\xi}{r(1+\varepsilon)} = \frac{\cos\alpha+\frac{\Delta\xi}{r}}{1+\varepsilon},$$

$$\frac{\Delta y+\Delta\eta}{r(1+\varepsilon)} = \frac{\cos\beta+\frac{\Delta\eta}{r}}{(1+\varepsilon)},$$

$$\frac{\Delta z+\Delta\zeta}{r(1+\varepsilon)} \quad \frac{\cos\gamma+\frac{\Delta\zeta}{r}}{1+\varepsilon} \qquad (7.)$$

In this case also the moving force will have for its projections, expressions analogous to those before given (4.), which will be

$$\mathrm{m}\ \mathrm{S}\left\{m\ \frac{\cos\alpha+\frac{\Delta\xi}{r}}{1+\varepsilon}\ \mathrm{f}\left(r\left(1+\varepsilon\right)\right)\right\}$$

$$\mathrm{m}\ \mathrm{S}\left\{m\ \frac{\cos\beta+\frac{\Delta\eta}{r}}{1+\varepsilon}\ \mathrm{f}\left(r\left(1+\varepsilon\right)\right)\right\} \qquad (8.)$$

$$\mathrm{m}\ \mathrm{S}\left\{m\ \frac{\cos\gamma+\frac{\Delta\zeta}{r}}{1+\varepsilon}\ \mathrm{f}\left(r\left(1+\varepsilon\right)\right)\right\}$$

For abbreviation, let us assume a function $f(r)$ such that we have

$$\frac{\mathrm{f}\left(r\left(1+\varepsilon\right)\right)}{1+\varepsilon} = \varepsilon f(r)+\mathrm{f}(r) \qquad (9.)$$

Also, by supposition, $\Delta\xi$, &c., and ε are very small quantities, so that terms of these quantities of two dimensions may be neglected. Combining this consideration with that of the equations (5.), we shall see that two terms will disappear from the coefficients of m in (8.) when expanded by introducing the value (9.), or those coefficients will take the form

$$\mathrm{S}\left\{m\ \frac{\mathrm{f}\,r}{r}\ \Delta\xi\right\}+\ \mathrm{S}\left\{m f(r)\,\varepsilon\cos\alpha\right\}$$

$$\mathrm{S}\left\{m\ \frac{\mathrm{f}\,r}{r}\ \Delta\eta\right\}+\ \mathrm{S}\left\{m f(r)\,\varepsilon\cos\beta\right\} \qquad (10.)$$

$$\mathrm{S}\left\{m\ \frac{\mathrm{f}\,r}{r}\ \Delta\zeta\right\}+\ \mathrm{S}\left\{m f(r)\,\varepsilon\cos\gamma\right\}.$$

Again, from equation (6.), on the same supposition of neglecting the powers above the 1st, we shall have a value of ε which will be,

$$\varepsilon = \frac{1}{r}\left(\cos\alpha\,\Delta\xi+\cos\beta\,\Delta\eta+\cos\gamma\,\Delta\zeta\right. \qquad (11.)$$

But the coefficients of m represent the accelerative force which solicits the molecule m due to the action of the molecules m, m', m'', &c. On the other hand, by the principles of dynamics, these accelerative forces parallel to the three axes will be expressed by the second differential coefficients of ξ, η, ζ, related to the variable t. If, then, we take the simplified expressions (10.), and introduce the value of ε (11.), we shall finally obtain the expressions

$$\frac{d^2\xi}{dt^2} = \left\{ \begin{array}{l} \quad \mathrm{S}\left\{m \dfrac{\mathrm{f}(r) + \cos^2\alpha f(r)}{r} \Delta\xi\right\} \\ + \mathrm{S}\left\{m \dfrac{\cos\alpha \cos\beta f(r)}{r} \Delta\eta\right\} \\ + \mathrm{S}\left\{m \dfrac{\cos\alpha \cos\gamma f(r)}{r} \Delta\zeta\right\} \end{array} \right.$$

$$\frac{d^2\eta}{dt^2} = \left\{ \begin{array}{l} \quad \mathrm{S}\left\{m \dfrac{\cos\beta \cos\alpha f(r)}{r} \Delta\xi\right\} \\ + \mathrm{S}\left\{m \dfrac{\mathrm{f}(r) + \cos^2\beta f(r)}{r} \Delta\eta\right\} \\ + \mathrm{S}\left\{m \dfrac{\cos\beta \cos\gamma f(r)}{r} \Delta\zeta\right\} \end{array} \right. \qquad (12.)$$

$$\frac{d^2\zeta}{dt^2} = \left\{ \begin{array}{l} \quad \mathrm{S}\left\{m \dfrac{\cos\gamma \cos\alpha f(r)}{r} \Delta\xi\right\} \\ + \mathrm{S}\left\{m \dfrac{\cos\gamma \cos\beta f(r)}{r} \Delta\eta\right\} \\ + \mathrm{S}\left\{m \dfrac{\mathrm{f}(r) + \cos^2\gamma f(r)}{r} \Delta\zeta\right\} \end{array} \right.$$

These are the differential equations, which will represent the motion of a system of molecules which, being subject to the action of mutual attractive or repulsive forces, are slightly disturbed from the positions which they occupy in the state of equilibrium of the system.

These equations are those before alluded to as being, in fact, the same which M. Cauchy has established in the memoir in his third volume. In the subsequent investigation in the fourth and fifth volumes, he at length deduces the well-known partial differential equation for vibrations (ε being the rectilinear displacement of a molecule and s a constant)

$$\frac{d^2\varepsilon}{dt^2} = s^2 \frac{d^2\varepsilon}{dr^2}$$

and from the form of its integral he establishes the laws of the propagation of the plane waves.

The celebrity of the discussions relative to this formula carried on by Euler and D'Alembert (Berlin Acts 1747), and decided by La Grange (Turin Memoirs 1759), as well as

the important considerations involved in the solution, are well known to mathematicians.

But it may not be useless for the student to bear in mind the connexion between the *form* of the function in its integration and the principle of the superposition of small motions arising from the circumstance of the *linearity* of the expression (in which case alone the differential coefficient of a sum of functions is the same as the sum of the differential coefficients). This point will be found illustrated in the particular view which M. Cauchy takes of the subject.

In his memoirs "On the Dispersion," &c., having established the above equations of motion (12.), he pursues from this point a different course to that adopted in his former memoirs; and from certain considerations which he lays down relative to the method of integration in this case, he is enabled to deduce expressions, from which not only are all the laws of the propagation of waves deducible as before, but also the other important relations to which we have alluded established.

[To be continued.]

IV. *Observations on the Production and Propagation of Sound. By* Charles J. B. Williams, *M.D., &c.**

IT is rather singular that so simple and comparatively easy a science as acoustics should have been so tardily developed, and that much of its recent advancement should be referrible rather to the illustrations which it affords to the sister science, optics, than to its own intrinsic value. So true is it that *sight* is our predominant sense, and that *darkness* and *ignorance* have become synonymous terms. Can it be a matter of wonder or of complaint that the organization of the ear is still involved in mystery, when so much of the laws of sound, to which it is doubtless adapted, is unappreciated or unexplained? We would venture to hope that some *master-spirit* will take up the subject of acoustics, not only as an interesting and instructive link between the mechanical sciences and those subtler ones of light, heat, and electricity, but also for its own sake, and for the support and improvement of those useful and agreeable relations to social happiness which depend on the perfect state of the sense of hearing. In the mean time I venture to bring before the

[* Communicated by the Author.—The substance of this paper was read before the Section of Mathematics and General Physics of the British Association, at the Meeting at Edinburgh in September 1834: see our last volume, p. 387.]

Association an attempt to give a greater precision to our ideas on this subject, in a few considerations which have resulted from the study of acoustics in connexion with its application to the distinction of diseases; and until they shall be confirmed by more competent authorities, I would advance the following remarks as inquiries, rather than as absolute assertions.

I. *On the Nature and Transfer of sonorous Vibrations.*

1. It is generally said in works on acoustics, that solids are good conductors of sound; but this expression requires qualification, for the power of bodies to transmit sound is not absolute, like the properties of conducting heat or electricity, but relative to the matter and form of the body from which the sound directly proceeds. Thus, the ticking of a watch is transferred to the ear perfectly through the longest piece of timber, but the sound of the voice or of a flute passes much more readily through the air*. As this subject is one of great importance in practical acoustics, and as it does not appear to have been developed to the extent of which it is capable, I may be permitted to enter a little minutely into the nature and progress of the motions constituting sound in various bodies.

2. All matter is susceptible of sonorous vibrations, and as a general rule, it may be stated that this susceptibility or capacity is in proportion to the strength and uniformity of the molecular elasticity in the matter. By *molecular elasticity* is meant that force by which the molecules of a body are held at a certain distance from each other, and resist any effort to displace them from it. Thus, glass and steel may be said to possess molecular elasticity in a powerful degree, because any external impulse is instantaneously communicated from particle to particle throughout their whole mass, and it is not lost or broken by the yielding or displacement of the molecules at the point struck. Air and other fluids, on the other hand, cannot be readily thrown into vibrations, unless the impulse be very forcible, or applied to some extent of surface, by which it becomes communicated to many particles at once.

3. Sound has been defined by Dr. Young and others, as

* Thus in Mr. Wheatstone's beautiful experiments with the "Enchanted Lyre" he could not succeed in transmitting, *by any contrivance*, the sound of the voice or a flute through a solid conductor without very great loss in the intensity of the sound; whereas the notes of solid cords or wires passed so little impaired by the transfer as to produce the magical effects of the instrument just mentioned. (See the last Numbers of the Journal of the Royal Institution.) It is hoped that the succeeding remarks in the text will explain the causes of these differences.

motion of a certain velocity*; but it is not simply this, for the velocity of wind, which is much greater than that of most initial soniferous impulses, does not suffice to produce sound, unless it meets with an obstacle; and certainly the movements of the earth and the heavenly bodies should, according to this definition, develop sound, and realize the poetic idea of "the music of the spheres." A more exact physical definition would be, *motion of a certain velocity resisted with a certain force*. The moving and the resisting forces, acting in opposite ways, constitute the vibrations of sound †.

4. The motion of matter producing sound should be considered as molecular, although the result is the motion of a mass. Let it be represented thus: an impulse being impinged on certain molecules, momentarily overcomes the resistance of their inertia, and causes them to start from their place; that force of repulsion which, existing between the different molecules, more or less strongly resists the attempt to approximate them, transfers the impulse from molecule to molecule, and thus extends it throughout the mass. The impulse that forced these molecules from their position being overcome by the reaction of the elastic forces, (attractive and repulsive,) these forces drive them back to beyond their proper station, whence, from the same cause, they again spring, until by a series of these alternating vibratory motions, the disturbing force is lost ‡. The assimilating or propagating power, then, of these vibrations depends on the repulsive and attractive forces (2.) of the molecules of the vibrating matter, and in proportion as these are strong to resist or react on a mechanical impulse, they will convert that impulse into a sonorous vibration (3.).

5. Uniformity or equality of molecular elasticity (2.) is

* "It appears that the only condition necessary for the production of a simple sound is a sufficient degree of velocity in the motion or impulse which occasions it."—*Dr. Young's Lectures*, vol. i. p. 378. Dr. Young here considered sound in a physiological sense. The paragraphs 2, 4 and 5, appeared in a chapter on Sound prefixed to my "Rational Exposition of Physical Signs," &c., published in 1828, some years before Sir John Herschel's articles in the *Encyclopædia Metropolitana* and Philosophical Magazine referred to in the Editors' notes below.

[† Sir John F. W. Herschel's implied definition (*Encycl. Metrop.*, Essay on Sound, art. 138,) is as follows: "Every impulse mechanically communicated to the air, or other sonorous medium, is propagated onward by its elasticity as a wave or pulse; but, in order that it shall affect the ear as an audible sound, a certain force and suddenness is necessary:" this, we apprehend, is virtually the same with Dr. Williams's definition in the text.—Edit.]

[‡ Illustrations of this subject will be found in Sir John F. W. Herschel's paper on the Absorption of Light by Coloured Media, Lond. and Edinb. Phil. Mag., vol. iii. p. 403—404.—Edit.]

equally necessary for the production and propagation of sonorous vibrations; for if the elasticity of some molecules be less than that of others, the reaction, being less prompt (4.), will produce vibrations not consentaneous with those of the others, and may impair or even destroy them, and this the more effectually the more irregular and varied these motions are. Hence in bodies of mixed density the vibrations do not continue, and the sound heard is only a stroke or knock.

Now, to understand more clearly the relative power of different conductors with regard to sound, we will take in contrast the relations of two, which differ greatly, steel and air.

6. When a piece of the former, freely suspended, is struck, the impulse is propagated through the particles in the manner just described (4.), until it is expended in forcing them into an excursion at the opposite surface: then, their elasticity coming into play will determine their recoil with a similar excursion on the other surface, and then back again, until the disturbing force is lost by friction, &c.* The continuance of the vibrations and the production of a tone are here independent of surrounding bodies. In air, on the other hand, one element of molecular elasticity (2. 4.), attraction, is wanting; hence, after an impulse has been applied to a body of it, this fails to produce a continued tone without the aid of reflecting walls of some denser matter.

7. Another remarkable difference between air and a sonorous solid is, that tones of volumes of the former become deeper in proportion to their size; whilst, up to a certain limit, enlarging the bodies of solids increases the rapidity of their vibrations, and therefore heightens their tones. The cause of this difference has been sufficiently investigated with regard to air; but although the fact is familiar, I have not met with a close examination of the cause of the lowering the tone of a solid by reducing its thickness. The greater proportional resistance of the air is not a sufficient reason, for the tone is nearly as much diminished *in vacuo*; and the diminished inertia of the thinner body would probably be enough to counterbalance this influence. The true cause I believe to be, that in solids of small thickness the impulse is not expended on reaching the opposite surface with the vibration proper to the material; hence the impulse continues to operate, and forces the particles into an increased and therefore prolonged excursion (6.), which, by causing further condensation, augments their elastic force, and enables them to overcome the impulse.

* See Sir John Herschel's paper on Absorption, as just referred to.—Edit.]

The mass is thus, by the superiority of the impulse over the combined normal resistance of the molecules of its diameter (6.), brought under a new law, from which it derives its altered tones. If the impulse be infinite, this law will find its limit in masses of the thickness of a vibration or wave of sound in the matter, which of course varies with its compressibility: in greater lengths, the impulse being efficiently reacted on by the proper elasticity of the material, and not continuing long enough to increase the sphere of the vibration, passes on as a wave, alternated with a counter-wave of reaction (3.). Such is the case with the longitudinal vibrations of rods, as illustrated by Chladni; and the law is fundamental to all the various simple sounds of solid bars, balls, plates, bells, and even wires and cords, the molecular elasticity being brought in these last into uniform force by extraneous tension. It would be endless to follow it through its extensive relations; but it may be noticed that one of the applications of the preceding view is to explain how (by increasing its excursions (7.),) thinning or beating out a mass of metal augments its power of impressing the air to a degree far greater than the reason usually assigned, increased contact, could account for.

8. Air is a bad conductor of the vibrations of solids, and solids are much worse conductors of the vibrations of air than air itself. The very different molecular elasticity (2. and 4.) of these two classes of matter is the obvious reason of this. Thus, a pulse of air coming against a hard surface, instead of overcoming the inertia of its molecules, so as to extend the vibration through the solid mass (4.), is first condensed, and then recoiling back by its own elasticity, constitutes an echo. The vibrations of a dense solid, on the other hand, as they are strong by the sturdy elasticity of the molecules (2. and 4.), so for the same reason, unless the impulse be very powerful in proportion to the mass, they are limited in their excursions. They, therefore, produce but minute vibrations in air, which being much less strongly elastic, requires longer pulses for a similar effect; and many direct vibrations are thus lost by the noiseless yielding (3.) of the air; oblique ones, by irregular refraction in passing into a medium of different density; and the few that are transferred are too weak to extend far.

9. The best mode of overcoming the difficulty of the transfer of vibrations from one medium to another is an interesting point, as it includes the principle of sounding-boards of musical instruments. We have already noticed that thinning a sonorous solid increases the sphere of its vibrations (7.), and therefore their power of affecting the air (8.); and provided that attention be paid to the direction of the vibrations, a similar

effect is obtained by connecting the sonorous solid, a tuning-fork, for instance, with an extended surface of thin metal of the same elasticity (2.). Such a metallic sounding-board greatly increases the sound, and to the ear applied on it, does so as much as a wooden one; but it is greatly inferior to this in extent of excursive vibration, and consequently in the volume of sound which it sends through the air (8.); besides which it is capable of producing sounds of its own that injure the purity of the original note. The superior power of wood in this respect, as the medium of transfer, will now be sufficiently clear. According to the experiments of Chladni, finely fibred fir-wood conducts sound along its fibres with nearly the same facility and velocity as steel. Such great molecular elasticity (2.) enables it to receive the slightest or most rapid vibrations uniformly from a vibrating solid, whilst from its lightness or small inertia (4.) these become sufficiently excursive to take full effect on the air, (8.); and no new or interfering sounds can be produced in the wood itself, because its want of uniform density across the grain would absorb or destroy any vibrations in a direction different from those of the sonorous bar or cord communicating with it. Messrs. Savart and Wheatstone have well illustrated the influence of the *form* and *position* of sounding-boards, with their effect of producing within themselves, and with the contained air, *vibrating systems*; but their *material* appears to have been in great measure overlooked. Examining the matter elementarily, we are led to point out *rigidity of longitudinal fibre*, by which the vibrations are equally and perfectly received from a sounding cord or bar (2. and 8.) and *lightness of mass*, by which they are made excursive and freely transferred to the air (4. and 7.), as the two most essential qualities for the materials of sounding-boards. These conclusions are quite in accordance with the experience of musical instrument makers, and, perhaps, may be useful in making this experience more rational and certain. The same properties render light rigid wood a good material for *stethoscopes*, which are intended to convey sounds of various media in the most direct way to the ear.

II. *On the Sounds of single and repeated Strokes.*

10. Single blows, such as those of a hammer on a nail or stone, are considered by Dr. Young and Sir John Herschel to consist of a single impulse (4. and 6.), and not of succesive vibrations, and therefore to have no pitch. Hence they describe a succession of these, as in the striking of the teeth of a cog-wheel against an object, as capable of producing musical tones in the same way and at the same ratio as the vibrations

of a cord. But although rapid revolutions of such a wheel, so as to make above 100 or 150 strokes in a second, do pass into continuous tones which can be referred to a particular pitch in the musical scale, yet the slower rotations do not produce a bass note, as an equal number of the vibrations of a cord, but only a succession of distinct *clicks*. This shows, I think, that the single clicks have a pitch, and that this is at the point where their succession begins to form a continued tone*.

11. That single strokes have a pitch, and consist of at least two vibrations ("semi-vibrations," Wheatstone), is further apparent to an ear accustomed to distinguish between musical notes, when they are made with different degrees of force: the gentle strokes are obviously lower than the forcible ones. The cause of this curious fact seems to be, that a forcible impulse, by momentarily increasing the density, accelerates the vibration. So also a very violent blow on a bell or bar, or a forcible pull of a cord, will make the initial vibrations quicker, and therefore the tone sharper, than in the proper note. This is perceptible in the loud notes of the harp: but the less yielding tension of metallic wires makes them still more liable to this change of tone; it is therefore most obvious in the twang of those instruments with wires, which are acted on by points projecting from a revolving barrel.

12. With the exception of this effect of force (14.), the note of continued sounds resulting from a rapid succession of strokes, which for convenience may be called *click sounds*, depends entirely on the frequency of these strokes (10.). In bodies of no given tension, this rapidity is most indeterminate and irregular; but in cords or bodies of a fixed key, when the series of impulses surpasses in rapidity the vibrations of the fundamental note, they will pass into its upper octave, or others of its higher harmonics. This is one reason why the bass cords of a violoncello, when bowed by an unskilful hand, give out various high and mixed notes, instead of the pure rich bass which those elicit who have experimentally acquired a mastery over the vibrations of the instrument.

13. Click sounds (10. and 12.) in bodies of no given ten-

* In attempting to excite a continued note as low as possible, M. Savart was obliged to abandon his toothed wheel, and use one with long vanes, which, by passing close to, but not touching, a lamina of pasteboard, produced in the air a series of concussions, which, if of a certain frequency, became a continued note. It is plain that the pitch of the single strokes here was exceedingly low, for the wheel was nearly five feet in diameter, and with this a very powerful continued but not uniform note resulted at the rate of seven or eight strokes per second.—*Annales de Chimie*, 1831.

sion constitute a large class of common noises, including grating, filing, planing, creaking of hinges, and all sounds of friction. The whistling caused by drawing the finger-nail quickly over a silk fabric is of the same kind, and owes its more musical character to the regularity of the threads. The highest audible sounds may be excited in this way. Dr. Wollaston noticed that the shrill notes of the bat and of some *Grylli* are inaudible to many ears. It is well remarked by Sir John Herschel, that one reason of this may be their very low force; and that if by mechanism we could strike on an anvil a hundred thousand blows in a second, there would be heard a most deafening shriek of still higher pitch. M. Savart produced an audible sound, by a wheel which gave in a second 24,000 strokes, which he counts as 48,000 vibrations, which are much higher than the limits of audibility assigned by Dr. Wollaston*. I believe that a higher sound is also elicited in the action of the wheel for the combustion of steel exhibited at the Gallery of Practical Science in Adelaide Street. This wheel is 11 inches in diameter, and revolves 8500 times in a minute, and when the steel touches it, some sounds are heard far too high to be named on any musical scale, yet superabundantly audible to all ears. Solid conductors would probably convey sounds too acute to be transmitted through the air (8.).

III. *On some Modifications of Echoes.*

14. The prolonged note produced by a succession of echoes from a series of palisades, and between two parallel walls, has been noticed by Dr. Young, Sir John Herschel, and others; but there are some points with respect to the latter instance that merit further consideration. Between two parallel surfaces, as two stone walls, or the ceiling and paved floor of a low room, the echo will take the character of a tone, prolonged in proportion to the reflecting power of the surfaces, and high in pitch in proportion to their nearness. The latter may be calculated roughly by dividing the velocity of sound through air by the distance of the reflecting surfaces. Each reflection constitutes a sound; and if these sounds reflected to the ear exceed in rate the vibrations of the original sound, the pitch of the echo will be raised in proportion (10.). But the pulses which fall obliquely, having a longer course, would necessarily be fewer, and reach the ear somewhat later; hence these echoes terminate in a lower key. This law of the modification of sound by repeated reflection explains a great many

* *Annales de Chimie*, 1830. [Dr. Wollaston's paper on this subject will be found in the Phil. Mag., vol. lvii. p. 187.—Edit.]

familiar phænomena; of these, two deserve notice as requiring further explanation.

15. The echoes of a large empty room are often of a lower pitch than the original sound; a whistle, for instance, although answered by a similar note, will also excite a number of echoes that are obviously lower. As this depth of echo is in proportion to the size of the room (14.), there is reason to believe that it arises from the various *stray pulses* falling into vibrations corresponding with their successive periods of reflection. Every room has its proper pitch of echo; and this depends on the relation of the prevailing diameter of the room to the velocity of sound through air. Thus, in a room 20 feet square, or, better, a circular one 20 feet in diameter, the principal echo of the room, besides the simple one, would consist of about 56 vibrations in a second.

16. Little reflecting cavities of a few inches' diameter must necessarily be still higher in their echoes (14.), and it is these echoes that give the tinkling sound to many hollow bodies when struck. The remarkable reverberation of empty barrels is a coarse instance; no sound of lower pitch will be reechoed within them. If the mouth of a glass or earthenware bottle be applied to the ear, and then tapped on the outside, each stroke will appear tinkling; and that this proceeds from the internal echo, and not from the material, is plain from the fact, that muffling the vessel in any way by the hand, or by a cloth, does not stop the tinkle of the interior, although heard externally the stroke is a mere dead *tap*. The peculiar ringing sound which accompanies blowing or whistling into a bottle is referrible to the same cause, and is quite distinct from the longitudinal vibration of the whole column of air excited by blowing laterally as with a Pan-pipe. Spherical cavities give the longest and most uniform echo, for the obvious reason that the reflections are nearly of the same length (14.).*

17. Very distant notes, such as street cries or the sound

* I was led to these facts in seeking the cause of a similar phænomenon which occurs in the human body, and is an important sign of disease. In pneumatoothorax, where a cavity is formed by air getting between the lungs and the walls of the chest, coughing or speaking is often attended by a tinkling echo, called by M. Laennec *tintement metallique*. I formerly ranked as of this kind the tinkling sound which occurs in the ear itself whenever it is closed, and the hand, or whatever is used to close it, is tapped: each stroke sounds like the clink of a piece of metal. But as I find that diminishing the cavity by introducing a small solid object far into the ear does not raise the tone, whereas forcing air through the Eustachian tube so as to press on the tympanum destroys the sound, I am inclined to think that the clink in question is produced by the vibration of the tympanum itself: accordingly I have found that in several who are slightly deaf in one ear, this note of the tympanum is higher in the ear that hears best.

of a horn, are often heard only in their upper octave. This singular fact I presume to depend on the greater strength of the moderately rapid vibrations, by which they are enabled to traverse a longer space than the fundamental note. The same thing occurs with distant echoes; and, although natural philosophers have not noticed this circumstance, melodramatists have successfully availed themselves of it to represent the effect of an echo on the stage. So also Shakspeare:

> "——— Babbling echo mocks the hounds,
> Replying *shrilly* to the well tuned horns."

Again,

> "Thy hounds shall make the welkin answer them,
> And fetch *shrill* echoes from their hollow earth."

Half-moon Street, Nov. 13, 1834.

V. *Experimental Researches in Electricity.—Eighth Series. By* Michael Faraday, *D.C.L. F.R.S. Fullerian Prof. Chem. Royal Institution, Corr. Memb. Royal and Imp. Acadd. of Sciences, Paris, Petersburgh, Florence, Copenhagen, Berlin, &c. &c.**

§. 14. *On the Electricity of the Voltaic Pile; its source, quantity, intensity, and general characters.* ¶ i. *On simple Voltaic Circles.* ¶ ii. *On the intensity necessary for Electrolyzation.* ¶ iii. *On associated Voltaic Circles, or the Voltaic Battery.* ¶ iv. *On the resistance of an Electrolyte to Electrolytic action.* ¶ v. *General remarks on the active Voltaic Battery.*

¶ i. *On simple Voltaic Circles.*

875. THE great question of the source of electricity in the voltaic pile has engaged the attention of so many eminent philosophers, that a man of liberal mind and able to appreciate their powers would probably conclude, although he might not have studied the question, that the truth was somewhere revealed. But if in pursuance of this impression he were induced to enter upon the work of collating results and conclusions, he would find such contradictory evidence, such equilibrium of opinion, such variation and combination of theory, as would leave him in complete doubt respecting what he should accept as the true interpretation of nature: he would be forced to take upon himself the labour of repeating

* From the Philosophical Transactions for 1834. Part II. p. 425. This paper was received by the Royal Society April 7th, and read June 5th, 1834.

and examining the facts, and then use his own judgement on them in preference to that of others.

876. This state of the subject must, to those who have made up their minds on the matter, be my apology for entering upon its investigation. The views I have taken of the definite action of electricity in decomposing bodies (783*.), and the identity of the power so used with the power to be overcome (855.), founded not on a mere opinion or general notion, but on facts which, being altogether new, were to my mind precise and conclusive, gave me, as I conceived, the power of examining the question with advantages not before possessed by any, and which might compensate, on my part, for the superior clearness and extent of intellect on theirs. Such are the considerations which have induced me to suppose I might help in deciding the question, and be able to render assistance in that great service of removing *doubtful knowledge*. Such knowledge is the early morning light of every advancing science, and is essential to its development; but the man who is engaged in dispelling that which is deceptive in it, and revealing more clearly that which is true, is as useful in his place, and as necessary to the general progress of the science, as he who first broke into the intellectual darkness, and opened a path into knowledge before unknown to man.

877. The identity of the force constituting the voltaic current or electrolytic agent, with that which holds the elements of electrolytes together (855.), or in other words with chemical affinity, seemed to indicate that the electricity of the pile itself was merely a mode of exertion, or exhibition, or existence of *true chemical action*, or rather of its cause; and I have consequently already said that I agree with those who believe that the *supply* of electricity is due to chemical powers (857.).

878. But the great question of whether it is originally due to metallic contact or to chemical action, *i. e.* whether it is the first or the second which *originates* and determines the current, was to me still doubtful; and the beautiful and simple experiment with amalgamated zinc and platina, which I have described minutely as to its results (863, &c.), did not decide the point; for in that experiment the chemical action does not take place without the contact of the metals, and the metallic contact is inefficient without the chemical action. Hence either might be looked upon as the *determining* cause of the current.

879. I thought it essential to decide this question by the

[* All the numbers referred to in Mr. Faraday's Eighth Series, now given, from 661 to 874 both inclusive, will be found in the Seventh Series, given in our last volume.—Edit.]

simplest possible forms of apparatus and experiment, that no fallacy might be inadvertently admitted. The well known difficulty of effecting decomposition by a single pair of plates, except in the fluid exciting them into action (863.), seemed to throw insurmountable obstruction in the way of such experiments; but I remembered the easy decomposibility of the solution of iodide of potassium (316.), and seeing no theoretical reason, if metallic contact was not *essential*, why true electro-decomposition should not be obtained without it, even in a single circuit, I persevered and succeeded.

880. A plate of zinc, about eight inches long and half an inch wide, was cleaned and bent in the middle to a right angle, fig. 1. *a.* Plate I. A plate of platina, about three inches long and half an inch wide, was fastened to a platina wire, and the latter bent as in the figure *b.* These two pieces of metal were arranged together as delineated, but as yet without the vessel *c*, and its contents, which consisted of dilute sulphuric acid mingled with a little nitric acid. At *x* a piece of folded bibulous paper, moistened in a solution of iodide of potassium, was placed on the zinc, and was pressed upon by the end of the platina wire. When under these circumstances the plates were dipped into the acid of the vessel *c*, there was an immediate effect at *x*, the iodide being decomposed, and iodine appearing at the *anode* (663.), *i.e.* against the end of the platina wire.

881. As long as the lower ends of the plates remained in the acid the electric current continued, and the decomposition proceeded at *x*. On removing the end of the wire from place to place on the paper, the effect was evidently very powerful; and on placing a piece of turmeric paper between the white paper and zinc, both papers being moistened with the solution of iodide of potassium, alkali was evolved at the *cathode* (663.) against the zinc, in proportion to the evolution of iodine at the *anode*. Hence the decomposition was perfectly polar, and decidedly dependent upon a current of electricity passing from the zinc through the acid to the platina in the vessel *c*, and back from the platina through the solution to the zinc at the paper *x*.

882. That the decompostion at *x* was a true electrolytic action, due to a current determined by the state of things in the vessel *c*, and not dependent upon any mere direct chemical action of the zinc and platina on the iodide, or even upon any *current* which the solution of iodide might by its action on those metals tend to form at *x*, was shown, in the first place, by removing the vessel *c* and its acid from the plates, when all decomposition at *x* ceased, and in the next by connecting

the metals, either in or out of the acid, together, when decomposition of the iodide at x occurred, but in a *reverse order*; for now alkali appeared against the end of the platina wire, and the iodine passed to the zinc, the current being the contrary of what it was in the former instance, and produced directly by the difference of action of the solution in the paper on the two metals. The iodine of course combined with the zinc.

883. When this experiment was made with pieces of zinc amalgamated over the whole surface (863.), the results were obtained with equal facility and in the same direction, even when only dilute sulphuric acid was contained in the vessel c (fig. 1.). Whichever end of the zinc was immersed in the acid, still the effects were the same: so that if, for a moment, the mercury might be supposed to supply the metallic contact, the reversion of the amalgamated piece destroys that objection. The use of *unamalgamated zinc* (880.) removes all possibility of doubt.

884. When, in pursuance of other views (930.), the vessel c was made to contain a solution of caustic potash in place of acid, still the same results occurred. Decomposition of the iodide was effected freely, though there was no metallic contact of dissimilar metals, and the current of electricity was in the *same direction* as when acid was used.

885. Even a solution of brine in the glass c could produce all these effects.

886. Having made a galvanometer with platina wires and introduced it into the course of the current between the platina plate and the place of decomposition x, it was affected, giving indication of currents in the same direction as those shown to exist by the chemical action.

887. If we consider these results generally, they lead to very important conclusions. In the first place they prove, in the most decisive manner, that *metallic contact is not necessary for the production of the voltaic current*. In the next place they show a most extraordinary mutual relation of the chemical affinities of the fluid which *excites* the current, and the fluid which is *decomposed* by it.

888. For the pupose of simplifying the consideration, let us take the experiment with amalgamated zinc. The metal so prepared exhibits no effect until the current can pass: it at the same time introduces no new action, but merely removes an influence which is extraneous to those belonging either to the production or the effect of the electric current under investigation (1000.); an influence also which, when present, tends only to confuse the results.

889. Let two plates, one of amalgamated zinc and the other of platina, be placed parallel to each other (fig. 2.), and intro-

duce a drop of dilute sulphuric acid, *y*, between them at one end: there will be no sensible chemical action at that spot unless the two plates are connected somewhere else, as at P Z, by a body capable of conducting electricity. If that body be a metal or certain forms of carbon, then the current passes, and, as it circulates through the fluid at *y*, decomposition ensues.

890. Then remove the acid from *y*, and introduce a drop of the solution of iodide of potassium at *x* (fig. 3.). Exactly the same set of effects occur, except that when the metallic communication is made at P Z, the electric current is in the opposite direction to what it was before, as is indicated by the arrows, which show the courses of the currents (667.).

891. Now *both* the solutions used are conductors, but the conduction in them is essentially connected with decomposition (858.) in a certain constant order, and therefore the appearance of the elements in certain places *shows* in what direction a current has passed when the solutions are thus employed. Moreover, we find that when they are used at opposite ends of the plates, as in the last two experiments (889. 890.), metallic contact being allowed at the other extremities, the currents are in opposite directions. We have evidently, therefore, the power of opposing the actions of the two fluids simultaneously to each other at the opposite ends of the plates, using each one as a conductor for the discharge of the current of electricity, which the other tends to generate; in fact, substituting them for metallic contact, and combining both experiments into one (fig. 4.). Under these circumstances there is an opposition of forces; the fluid, which brings into play the stronger set of chemical affinities for the zinc (being the dilute acid,) overcomes the force of the other, and determines the formation and direction of the electric current; not merely making that current pass through the weaker liquid, but actually reversing the tendency which the elements of the latter have in relation to the zinc and platina if not thus counteracted, and forcing them in the contrary direction to that they are inclined to follow, that its own current may have free course. If the dominant action at *y* be removed by making metallic contact there, then the liquid at *x* resumes its power; or if the metals be not brought into contact at *y*, but the affinities of the solution there weakened, whilst those active at *x* are strengthened, then the latter gains the ascendancy, and the decompositions are produced in a contrary order.

892. Before drawing a *final* conclusion from this mutual dependence and state of the chemical affinities of two distant portions of acting fluids (916.), I will proceed to examine more minutely the various circumstances under which the reaction of the decomposed body is rendered evident upon the

action of that body, also in the act of decomposition, which produces the voltaic current.

893. The use of *metallic contact* in a single pair of plates, and the cause of its great superiority above contact made by other kinds of matter, become now very evident. When an amalgamated zinc plate is dipped into dilute sulphuric acid, the force of chemical affinity exerted between the metal and the fluid is not sufficiently powerful to cause sensible action at the surfaces of contact, and occasion the decomposition of water by the oxidation of the metal, although it *is* sufficient to produce such a condition of the electricity (or the power upon which chemical affinity depends) as would produce a current if there were a path open for it (916. 956.); and that current would complete the conditions necessary, under the circumstances, for the decomposition of the water.

894. Now the presence of a piece of platina touching both the zinc and the fluid to be decomposed, opens the path required for the electricity. Its *direct communication* with the zinc is effectual, far beyond any communication made between it and that metal, (*i. e.* between the platina and zinc,) by means of decomposable conducting bodies, or, in other words, *electrolytes*, as in the experiment already described (891.); because, when they are used, the chemical affinities between them and the zinc produce a contrary and opposing action to that which is influential in the dilute sulphuric acid; or if that action be but small, still the affinity of their component parts for each other has to be overcome, for they cannot conduct without suffering decomposition: and this decomposition is found *experimentally* to react back upon the forces which in the acid tend to produce the current (904. 910. &c.), and in numerous cases entirely to neutralize them. Where direct contact of the zinc and platina occurs, these obstructing forces are not brought into action, and therefore the production and the circulation of the electric current and the concomitant action of decomposition are then highly favoured.

895. It is evident, however, that one of these opposing actions may be dismissed, and yet an electrolyte be used for the purpose of completing the circuit between the zinc and platina immersed separately into the dilute acid; for if, in fig. 1, the platina wire be retained in metallic contact with the zinc plate *a*, at *x*, and a division of the platina be made elsewhere, as at *s*, then the solution of iodide placed there, being in contact with platina at both surfaces, exerts no chemical affinities for that metal; or if it does, they are equal on both sides. Its power, therefore, of forming a current in opposition to that dependent upon the action of the acid in the vessel *c*, is removed, and only its resistance to decomposition remains as

the obstacle to be overcome by the affinities exerted in the dilute sulphuric acid.

896. This becomes the condition of a single pair of plates where *metallic contact* is allowed. In such cases, only one set of opposing affinities are to be overcome by those which are dominant in the vessel *c*; whereas, when metallic contact is not allowed, two sets of opposing affinities must be conquered (894.).

897. It has been considered a difficult, and by some an impossible, thing to decompose bodies by the current from a single pair of plates, even when it was so powerful as to heat bars of metal red hot, as in the case of Hare's calorimeter, arranged as a single voltaic circuit, or of Wollaston's powerful single pair of metals. This difficulty has arisen altogether from the antagonism of the chemical affinity engaged in producing the current with the chemical affinity to be overcome, and depends entirely upon their relative intensity; for when the sum of forces in one has a certain degree of superiority over the sum of forces in the other, the former gains the ascendancy, determines the current, and overcomes the latter forces so as to make the substance exerting them yield up its elements in perfect accordance, both as to direction and quantity, with the course of those which are exerting the most intense action.

898. Water has generally been the substance, the decomposition of which has been sought for as a chemical test of the passage of an electric current. But I now began to perceive a reason for its failure, and for a fact which I had observed long before (315. 316*.) with regard to the iodide of potassium, namely, that bodies would differ in facility of decomposition by a given electric current, according to the condition and intensity of their ordinary chemical affinities. This reason appeared in their reaction back upon the affinities tending to cause the current; and it appeared probable, that many substances might be found which could be decomposed by the current of a single pair of zinc and platina plates immersed in dilute sulphuric acid, although water resisted its action. I soon found this to be the case, and as the experiments offer new and beautiful proofs of the direct relation and opposition of the chemical affinities concerned in producing and in resisting the stream of electricity, I shall briefly describe them.

899. The arrangement of the apparatus was as in fig. 5. The vessel *v* contained dilute sulphuric acid; Z and P are the zinc and platina plates; *a*, *b*, and *c* are platina wires; the de-

[* These numbers refer to part of the author's Third Series of Researches in Electricity, which will be found in Lond. and Edinb. Phil. Mag. vol. iii. p. 254.—Edit.]

compositions were effected at x, and occasionally, indeed generally, a galvanometer was introduced into the circuit at g: its place only is here given, the circle at g having no reference to the size of the instrument. Various arrangements were made at x, according to the kind of decomposition to be effected. If a drop of liquid was to be acted upon, the two ends were merely dipped into it; if a solution contained in the pores of paper was to be decomposed, one of the extremities was connected with a platina plate supporting the paper, whilst the other extremity rested on the paper, e, fig. 12: or sometimes, as with sulphate of soda, a plate of platina sustained two portions of paper, one of the ends of a and c resting upon each piece, c, fig. 14. The darts represent the direction of the electric current (667.).

900. Solution of *iodide of potassium*, being placed in moistened paper at the interruption of the circuit at x, was readily decomposed. Iodine was evolved at the *anode*, and alkali at the *cathode*, of the decomposing body.

901. *Protochloride of tin*, when fused and placed at x, was also readily decomposed, yielding perchloride of tin at the *anode* (779.), and tin at the *cathode*.

902. Fused chloride of silver, placed at x, was also easily decomposed; chlorine was evolved at the *anode*, and brilliant metallic silver, either in films upon the surface of the liquid, or in crystals beneath, evolved at the *cathode*.

903. Water acidulated with sulphuric acid, solution of muriatic acid, solution of sulphate of soda, fused nitre, and the fused chloride and iodide of lead were not decomposed by this single pair of plates, excited only by dilute sulphuric acid.

904. These experiments give abundant proofs that a single pair of plates can electrolyze bodies and separate their elements. They also show in a beautiful manner the direct relation and opposition of the chemical affinities concerned at the two points of action. In those cases where the sum of the opposing affinities at x was sufficiently beneath the sum of the acting affinities in v, decomposition took place; but in those cases where they rose higher, decomposition was effectually resisted and the current ceased to pass (891.).

905. It is, however, evident, that the sum of acting affinities in v may be increased by using other fluids than dilute sulphuric acid, in which latter case, as I believe, it is merely the affinity of the zinc for the oxygen already combined with hydrogen in the water that is exerted in producing the electric current (919.): and when the affinities are so increased, the view I am supporting leads to the conclusion, that bodies which resisted in the preceding experiments would then be decomposed, because of the increased difference between their

affinities and the acting affinities thus exalted. This expectation was fully confirmed in the following manner.

906. A little nitric acid was added to the liquid in the vessel *v*, so as to make a mixture which I shall call diluted nitro-sulphuric acid. On repeating the experiments with this mixture, all the substances before decomposed again gave way, and much more readily. But besides that, many which before resisted electrolyzation now yielded up their elements. Thus, solution of sulphate of soda, acted upon in the interstices of litmus and turmeric paper, yielded acid at the *anode* and alkali at the *cathode*; solution of muriatic acid tinged by indigo yielded chlorine at the *anode*, and hydrogen at the *cathode*; solution of nitrate of silver yielded silver at the *cathode*. Again, fused nitre and the fused iodide and chloride of lead were decomposable by the current of this single pair of plates though they were not by the former (903.).

907. A solution of acetate of lead was apparently not decomposed by this pair, nor did water acidulated by sulphuric acid seem at first to give way (973.).

908. The increase of intensity or power of the current produced by a simple voltaic circle, with the increase of the force of the chemical action at the exciting place, is here sufficiently evident. But in order to place it in a clearer point of view, and to show that the decomposing effect was not at all dependent, in the latter cases, upon the mere capability of evolving *more* electricity, experiments were made in which the quantity evolved could be increased without variation in the intensity of the exciting cause. Thus the experiments in which dilute sulphuric acid was used (899.) were repeated, using large plates of zinc and platina in the acid; but still those bodies which resisted decomposition before, resisted it also under these new circumstances. Then again, where nitro-sulphuric acid was used (906.), mere wires of platina and zinc were immersed in the exciting acid; yet, notwithstanding this change, those bodies were now decomposed which resisted any current tending to be formed by the dilute sulphuric acid. For instance, muriatic acid could not be decomposed by a single pair of plates when immersed in dilute sulphuric acid; nor did making the sulphuric acid strong, nor enlarging the size of the zinc and platina plates immersed in it, increase the power; but if to a weak sulphuric acid a very little nitric acid was added, then the electricity evolved had power to decompose the muriatic acid, evolving chlorine at the *anode* and hydrogen at the *cathode*, even when mere wires of metals were used. This mode of increasing the intensity of the electric current, as it excludes the effect dependent upon many pairs of plates, or even the effect of making any one acid stronger

or weaker, is at once referrible to the condition and force of the chemical affinities which are brought into action, and may, both in principle and practice, be considered as perfectly distinct from any other mode.

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909. The direct reference which is thus experimentally made in the simple voltaic circle of the *intensity* of the electric current to the *intensity* of the chemical action going on at the place where the existence and direction of the current is determined, leads to the conclusion that by using selected bodies, as fused chlorides, salts, solutions of acids, &c., which may act upon the metals employed with different degrees of chemical force; and using also metals in association with platina, or with each other, which shall differ in the degree of chemical action exerted between them and the exciting fluid or electrolyte, we should be able to obtain a series of comparatively constant effects due to electric currents of different intensities, which would serve to assist in the construction of a scale so as to supply the means of determining relative degrees of intensity accurately in future researches.

910. I have already expressed the view which I take of the decomposition in the experimental place, as being the direct consequence of the superior exertion at some other spot of the same kind of power as that to be overcome, and therefore as the result of an antagonism of forces of the *same* nature (891. 904.). Those at the place of decomposition have a reaction upon, and a power over, the exerting or determining set proportionate to what is needful to overcome their own power; and hence a curious result of *resistance* offered by decompositions to the original determining force, and consequently to the current. This is well shown in the cases where such bodies as chloride of lead, iodide of lead, and water would not decompose with the current produced by a single pair of zinc and platina plates in sulphuric acid (903.), although they would with a current of higher intensity produced by stronger chemical powers. In such cases no sensible portion of the current passes (967.); the action is stopped: and I am now of opinion that in the case of the law of conduction which I described in the Fourth Series of these Researches (413.*), the bodies which are electrolytes in the fluid state cease to be such in the solid form, because the attractions of the particles by which they are retained in combination and in their relative position, are then too powerful for the electric current. The particles retain their places; and as decomposition is prevent-

[* An abstract of Mr. Faraday's Fourth Series, stating the nature of the law of conduction in question, was given in Lond. and Edin. Phil. Mag., vol. iii. pp. 449, 450.—Edit.]

ed, the transmission of the electricity is prevented also; and although a battery of many plates may be used, yet if it be of that perfect kind which allows of no extraneous or indirect action (1000.), the whole of the affinities concerned in the activity of that battery are at the same time also suspended and counteracted.

911. But referring to the *resistance* of each single case of decomposition, it would appear that as these differ in force according to the affinities by which the elements in the substance tend to retain their places, they also would supply cases constituting a series of degrees by which to measure the initial intensities of simple voltaic or other currents of electricity, and which, combined with the scale of intensities determined by different degrees of *acting force* (909.), would probably include a sufficient set of differences to meet almost every important case where a reference to intensity would be required.

912. According to the experiments I have already had occasion to make, I find that the following bodies are electrolytic in the order in which I have placed them, those which are first being decomposed by the current of lowest intensity. These currents were always from a single pair of plates, and may be considered as elementary *voltaic forces.*

Iodide of potassium (solution).
Chloride of silver (fused).
Protochloride of tin (fused).
Chloride of lead (fused).
Iodide of lead (fused).
Muriatic acid (solution).
Water, acidulated with sulphuric acid.

913. It is essential that in all endeavours to obtain the relative electrolytic intensity necessary for the decomposition of different bodies, attention should be paid to the nature of the electrodes, and [to that of] the other bodies present which may favour secondary actions (986.). If in electro-decomposition one of the elements separated has an affinity for the electrode, or for bodies present in the surrounding fluid, then the affinity resisting decomposition is in part balanced by such power, and the true place of the electrolyte in a table of the above kind is not obtained: thus, chlorine combines with a positive platina electrode freely, but iodine scarcely at all, and therefore I believe it is that the chloride stands first in the preceding table. Again, if in the decomposition of water not merely sulphuric but also a little nitric acid be present, then the water is more freely decomposed, for the hydrogen at the *cathode* is not ultimately expelled, but finds oxygen in the nitric acid, with which it can combine to produce a secondary result; the affinities opposing decomposition are in this way diminished,

and the elements of the water can then be separated by a current of lower intensity.

914. Advantage may be taken of this principle to interpolate more minute degrees into the scale of initial intensities already referred to (909. 911.) than is there supposed; for by combining the force of a current *constant* in its intensity, with the use of electrodes consisting of matter having more or less affinity for the elements evolved from the decomposing electrolyte, various intermediate degrees may be obtained.

[To be continued.]

VI. *On the approaching Return of Halley's Comet. By Dr.* Olbers. *Translated from* Schumacher's *Astronomische Nachrichten, No.* 268, *for the Royal Astronomical Society, by* T. Galloway, *Esq., and read at the Meeting of the Society, on the 12th of December* 1834.

THE precise day on which Halley's comet will make its nearest approach to the sun in the year 1835, cannot be previously determined with certainty, although by the labours of some of the most distinguished astronomers and geometers this point of time has been determined within pretty narrow limits. The complicated, tedious, and wearisome calculations required for computing the perturbations do not give the same results to different computers. Damoiseau found the time of passing the perihelion to be November 4·32 days; Pontécoulant, November 7·2. The computations of Professor Rosenberger, which have been made with the utmost possible care, exactness, and accuracy, are not yet completed; but from such parts of them as have hitherto been made public, it appears that the comet will not pass its perihelion before the 11th of November at the soonest, even taking into account the resistance of the æther, which, according to his computation, may cause an acceleration of about four days*. But the effect of the resistance of the æther upon Halley's comet cannot be computed. From its effect on Encke's comet, which is known by experience, no conclusion whatever can be formed of its effect on the comet of Halley. 1st. The effect of the resisting medium is necessarily a function of the volume and of the mass of the comet; but the two comets (Encke's and Halley's) differ greatly in respect both of mass and volume, though in what proportions they differ we know not. 2nd. The arbitrary hypothesis of Newton, that the density of the resisting medium, or of the ætherin the regions of space, diminishes as the square

[* Prof. Rosenberger's determination of the elements of Halley's comet at its last appearance (1759), will be found in Phil. Mag. and Annals, N.S., vol. xi. p. 32.—Edit.]

of the distance from the sun increases, is still extremely doubtful. A density assumed to diminish less rapidly than according to this law, would have a great influence on the motion of a comet which describes so much larger an orbit than Encke's. Santini found the acceleration of Biela's comet, computed on this hypothesis, to be 0·03 of a day; whereas experience gave 0·45, if not even 0·90 of a day. This likewise seems to make it probable that the density of the æther diminishes more slowly, and according to a different law; perhaps the law of the ordinates of a logarithmic curve. 3rd. It is not improbable that the resisting medium is not at rest, but has a direct rotatory motion about the sun. Even the perpetual revolution of the planets must at length communicate to the æther through which they move a direct motion of rotation; but I am of opinion that such a motion is coeval with the formation of our planetary system, and was originally connected with it. Now, granting the direct motion of the resisting medium, its effect on a comet whose motion is retrograde, like Halley's, will be entirely different from its effect on one whose motion is direct, like Encke's. Experience alone can determine the amount of the influence which the resistance of the æther has on the period of revolution of Halley's comet. We have, it is true, the experience afforded by the return of the comet to its perihelion in 1759; but in order to know precisely how much sooner the comet arrived at its perihelion in 1759 through the effect of resistance of the æther, it is indispensable to compute, with the strictest accuracy, the amount of the perturbations between 1607 and 1682. This would double the enormous calculations which astronomers have undertaken for the purpose of computing its return in 1835; a labour too arduous to be expected of them, at least it has not yet been executed by any one.

Clairaut, when he undertook to calculate the return of Halley's comet in 1759, did not content himself with computing merely the perturbations from 1607 to 1682; he likewise computed their amount for the revolution between 1531 and 1607. According to the results given by him in the *Recherches sur la Comète* (Petersburg 1762), in which the first calculations published in the *Théorie des Comètes* (Paris 1761) are revised and in part corrected, the comet arrived at its perihelion, both in 1682 and 1759, about 23 or 24 days before its computed time. But no inference can be drawn from this as to the actual amount of the influence of the resisting medium, in as much as Clairaut was unacquainted with the existence of Uranus, and assumed the mass of Saturn much too great, namely $= \frac{1}{3021}$.

On account of this uncertainty as to the time of the perihe-

lion passage of Halley's comet next year, it becomes an object of greater interest to observe it as soon as possible, and we are naturally led to inquire whether it will not be visible during the winter, or early in the spring of 1835. Ferrer and Wisniewsky had the good fortune to rediscover the comet of 1811 in July and August 1812, when it was at a greater distance from the sun, and at least at as great a distance from the earth, as Halley's will be in February and March 1835. Whether it will be visible or not depends principally, as has been often noticed, on its distance from the sun. A comet does not escape observation in our telescopes from the smallness of its size, but from insufficient brightness to enable it to be discerned in the sky. I am indeed far from supposing that Halley's comet is as large, or under similar circumstances as easily seen, as the splendid comet of 1811; but 1st, All the former observers of Halley's comet represent the head as particularly brilliant. The nucleus resembled a fixed star (*Pingré*, i. p. 460). Hevel says of its appearance in 1682, (*Annus Climactericus*, p. 123.) "Toto apparitionis tempore lucidius et aliquanto majus caput exhibuit quam præcedens ille anno 1681." On the 22nd of September, he observes (p. 121.), "conspectum tamen est caput cometæ tubo optico ad exordium ipsum solis, ob clarissimum nucleum quem in meditullio referebat." Robert Hooke also, (*Posthumous Works*, p. 161,) with others, was able to see the comet on the 4th (14th) of September even till the time of its setting. "I was able to see it almost to the very horizon, even till it went behind a steeple, a little above the tops of the houses, though the smoke much thickened the air." 2nd. About the middle of March 1835 it will be more strongly illuminated by the sun, in the proportion of 8 : 5, than the comet of 1811 was on the 17th of August, when Wisniewsky finally saw and observed it. And 3rd, which is of most importance, Ferrer found the latter comet on the 10th of July 1812 with a comet-sweeper, and Wisniewsky was still able to observe it on the 17th of August with a common 3½ feet achromatic; whereas in searching for Halley's comet there is nothing to prevent us from employing great refractors or reflectors which render even the faintest nebulæ visible.

When I refer to the appearance of Halley's comet in 1682, I assume, indeed, that it has not sustained since that time any sensible diminution of mass or matter. Many astronomers consider a gradual diminution of the matter of comets to be probable, since such of them as appear with tails must throw off and lose a great portion of the matter of their tails at each return to their perihelia. Experience has given no information on this point with respect to Halley's comet. Although in 1607, and at its last apparition in 1759,

it appeared pale and comparatively dim, it shone forth again with great splendour in 1682; and the fainter appearances of 1607 and 1759 may be explained by its position in those years in respect of the earth and the sun, without supposing it to have suffered any actual diminution. Perhaps we are only ignorant where the comets, in accomplishing their wide revolutions, again recover the splendour they lose when near their perihelia.

I should mention, however, that Messier, who endeavoured to follow every comet as long as possible, was not able to observe Halley's comet in 1759 after the 4th of June, when its distance from the sun was only about 1·68, and from the earth 1·42. It cannot be denied that, according to the commonly received theory, this comet in February and March 1835 will be 4 or 5 times less illuminated, and the intensity of its light about 30 times less than it was on the 4th of June 1759. But at that time the comet set almost in the evening twilight; at least when the twilight had become sufficiently feeble, it was very near the horizon: and Messier likewise made use of very common telescopes. In March 1835, when the evening twilight has completely disappeared, the comet will be still high up in the sky, and may be sought for with refracting or reflecting telescopes of far greater optical power. That Halley's comet, as the experience of 1822 and 1832 has undoubtedly shown to be the case with Encke's, will be visible at a much greater distance from the sun and the earth before it has passed its perihelion than after, is a position which I will not take upon me to maintain*.

* This very interesting and remarkable property of Encke's comet has not hitherto, so far as I am aware, been sufficiently attended to. According to theory, the intensity of the light of a celestial body not self-luminous, is $=\frac{M}{R^2 D^2}$, where R and D denote the distances from the sun and the earth, and M depends on the magnitude and nature of the individual body. When M is constant, the intensity of the light is proportional to $C=\frac{1}{R^2 D^2}$. Pons discovered Encke's comet in 1818 when $C=0·936$. Afterwards, when its place had been previously computed by Encke, astronomers were able to find it in 1825 and 1828 when C had a much smaller value. At its discovery in 1805, C was $=7·26$, and then it was seen with the naked eye, and appeared equal to a star of the 4th magnitude. But after it had passed the perihelion, Rumker, in 1822, lost sight of it when C was $=15·18$. On its reappearance in 1832, when the value of C was $=12·12$, two observers, Henderson and Mossotti, describe its light as being very feeble; and Mr. Henderson could neither see it with the naked eye nor in the telescope, when C was still $=7·97$, and consequently greater than in 1805 when it appeared equal to a star of the 4th magnitude. It would seem that the effect of the sun's rays in the inferior part of the orbit is to dilute so greatly the light vapours of which this comet seems to be entirely composed, that the exterior particles become invisible, and even the parts nearer the centre of

However doubtful it may remain whether it will be possible to see the comet before its conjunction, yet an attempt to find it may be easily made; and even an unsuccessful result will afford some information with respect to the proportion it bears to the comet of 1811. With a view to afford all possible facility to the discovery, I subjoin a double ephemeris of Halley's comet. By the first I find the 1st of November, and by the second the 11th, to be the day on which it will pass its perihelion. Most probably the passage of the perihelion will take place between these two days. The following elements are taken from Pontécoulant:

Eccentricity	0·9675212
Longitude of perihelion	304° 31′ 43″
☊	55 30 0
Inclination of the orbit	17 44 24
Greater semiaxis	17·99711
Mean daily motion	46″·475058

M. Pontécoulant makes the greater semiaxis = 17·98705, and the mean daily motion = 46″·512265. But a slight oversight has been committed with respect to this last quantity. Pontécoulant has added the integral of $d\,n$ for 1682 = 0·373945 instead of $\int d\,n$ for 1759 = 0·3367382 to N′, and thus brings out N″ = 46·512265 instead of N″ = 46·475058; and from this incorrect value of N″ he has deduced the greater semiaxis. The following are the places of the comet for mean midnight at Berlin:

Perihelion Passage, November 1·5, 1835.

Time.	Æ in time. (h m)	Declination.	Log. distance from ☉.	Log. distance from ♁.
1834. Dec. 22·5	5 23·9	+12°20′	0·6448	0·5384
1835. Jan. 1·5	5 9·2	12 21	0·6347	0·5322
11·5	4 55·1	12 25	0·6243	0·5308
25·5	4 42·1	12 33	0·6131	0·5333
31·5	4 31·1	12 45	0·6024	0·5402
Feb. 10·5	4 22·0	13 2	0·5908	0·5482
20·5	4 15·1	13 22	0·5787	0·5580
March 2·5	4 10·4	13 45	0·5662	0·5676
12·5	4 7·6	14 12	0·5528	0·5751
22·5	4 6·7	14 39	0·5392	0·5834
April 1·5	4 7·2	15 14	0·5248	0·5887

gravity less capable of reflecting the sun's light; and that as the distance of the comet from the sun becomes greater, its volume is again contracted, and its dispersed constituent particles re-united.

Perihelion Passage, November 11·5, 1835.

Time.	Æ in time.	Declination.	Log. distance from ☉.	Log. distance from ♁.
	h m			
1834. Dec. 22·5	5 26·9	+12°17′	0·6745	0·5503
1835. Jan. 1·5	5 12·6	12 17	0·6448	0·5444
11·5	4 58·8	12 22	0·6347	0·5429
21·5	4 46·3	12 31	0·6243	0·5457
31·5	4 35·3	12 43	0·6131	0·5514
Feb. 10·5	4 26·2	12 59	0·6024	0·5599
20·5	4 19·7	13 20	0·5908	0·5691
March 2·5	4 15·1	13 43	0·5787	0·5787
12·5	4 12·4	14 10	0·5662	0·5869
22·5	4 11·4	14 39	0·5528	0·5939
April 1·5	4 12·3	15 2	0·5392	0·5996

Though the distance of the comet from the earth begins again to increase after the first half of January, this will be more than compensated by its progressive approach to the sun. Besides, the probability of being able to see the comet will be greatest, not at the time of the opposition, or soon after it, but in February and March.

Some writers have excited in the public greatly exaggerated ideas of the splendour and brilliancy with which, as they pretend, the comet will appear in October 1835. The expectations thus raised will greatly fail to be realized. The comet will, on the whole, rather exhibit the same degree of luminousness as in 1607, which Kepler describes, and does not speak of as being particularly remarkable. It will be far inferior to the comet of 1811, and probably resemble the third comet of 1825*, when this last was in its most favourable position with respect to our horizon, and which made no great impression on the bulk of the people. Only the head of Halley's comet will probably appear brighter and more remarkably formed than that of the comet of 1825. We have four different delineations of Halley's comet as it appeared in the telescope in 1682; one by Hevel in the *Annus Climactericus*, as it was seen by him on the 8th of September (Hevel had previously published this drawing in the *Acta Eruditorum*, 1682); and three in the *Posthumous Works* of R. Hooke. The

* Under the bright sky of Florence, Inghirami was able to follow and observe this comet from 1825 to the 8th of July 1826. (*Astr. Nachr.*, v. Band, p. 150.) At that time the distance of the comet from the sun was 3·147, which differs little from the distance of Halley's comet from the sun on the 22nd of March 1835, viz. 3·461. This circumstance must greatly strengthen the hope of seeing Halley's comet in the spring of 1835.

drawings in the latter work are very inaccurate, as they had only been roughly sketched by Hooke for the purpose of aiding his memory, and were finished by Richard Waller, from Hooke's description (*P. Works*, p. 164); yet they illustrate what appears extraordinary in Hevel's drawing, and show that the nucleus of this comet, besides the usual nebulous envelope, was inclosed within a hollow parabolic conoid of bright matter of the same nature as the tail, resembling in some measure, it would seem, the comet of 1811. The nucleus, however, in Halley's comet was in immediate contact with the apex of the conoid; whereas, in the comet of 1811, the apex of the conoid was separated from the nucleus by a dark interval of considerable extent. What Hevel represents as a horn proceeding from the nucleus, was merely the northern border of the conoid, which, according to Hooke, is very much brighter than the southern. It is to be expected that on its approaching return astronomers will bestow all possible attention on the remarkable peculiarities of form which it will probably only exhibit after the perihelion, and on the changes of appearances it undergoes. In the drawing made by Tobias Mayer, on the margin of his Journal, 30th of April 1759, ("Astronomical Observations made at Göttingen, from 1756 to 1761, &c., London 1826, fol. p. 43.") no indication is given of this bright conoid, which, 48 days after the comet's nearest approach to the sun, had entirely disappeared.

Although the comet, on this occasion, will not exhibit any extraordinary splendour, yet the circumstances of its return will be favourable to science, as it will be possible to see and observe it during a considerable length of time. In the southern hemisphere of our earth, where, thanks to Great Britain, several observatories have been erected, and competent astronomers established, the comet will be seen on extricating itself from the sun's rays, after the perihelion passage, from about the end of December 1835, till the spring of 1836. In the North of Europe, indeed, on account of its continual low altitude above the horizon, it will come less into view; and when in the months of March and April 1836, it has attained to a greater height in the constellations of the Crow and the Cup, it will be at so great a distance from the sun and the earth, that it will appear only as a feeble nebula in the most powerful telescopes.

While engaged in writing out the last part of this short memoir, I was equally honoured and gratified by receiving an entirely unexpected visit from Professor Rosenberger. Professor Rosenberger is also fully convinced that it is not

possible, on account of the still undetermined resistance of the æther, to predict with any certainty the precise day of the perihelion passage in 1835, without computing the amount of the perturbations from 1607 to 1682. As there is no longer time for this, he has resolved to suspend for the present his calculation of the perturbations from 1759 to 1835, which he has already carried so far as 270° of eccentric anomaly, and to wait the result of experience. He will then resume his calculations, and carry them back to 1607, in order that the effect of the resistance of the æther on this comet may be determined with all possible accuracy.

OLBERS.

VII. *On the Quantity of Water contained in crystallized Barytes and Strontia. By* RICHARD PHILLIPS, *F.R.S. L. & E. &c., Lecturer on Chemistry at St. Thomas's Hospital.*

DR. DALTON in his Chemical Philosophy (vol. i. p. 523.) states that he found that 80 grains of fresh crystallized barytes, dissolved in water and saturated with sulphuric acid, gave 36 grains of dried sulphate of barytes; and hence he infers, that in the crystals 20 atoms of water are united to one atom of barytes. On looking into chemical works I do not find that any other chemist has attempted to ascertain the quantity of water which these crystals contain; indeed Dr. Dalton's statement is quoted by both Thomson and Turner.

Not remembering any case in which a binary compound like barytes unites with so many as 20 equivalents of water, and as Dr. Dalton admits that his experience on the crystals of barytes has been limited, I was induced to repeat the experiment, in order to ascertain whether or not these crystals formed an exception to what appears to me to be a general rule.

With this intention I decomposed some sulphate of barytes by heating it with charcoal, and dissolving the sulphuret of barium in water: the solution was heated with peroxide of copper, and filtered while hot. On cooling, crystals of barytes were plentifully obtained, which were dried, as well as they could be, by repeated pressure between folds of blotting-paper. One hundred parts of these crystals were supersaturated with muriatic acid, and the solution was decomposed by sulphuric acid: in one experiment 72·19 parts and in another 72·15 parts of sulphate of barytes were obtained, giving a mean of 72·17; now as 116 of sulphate of barytes contain 76 of the earth, 72·17 parts contain 47·28 of barytes, which, deducted from 100, the crystals employed, leave 52·72 as the quantity of water which they contained. Now a compound of

$$\left.\begin{array}{ll}\text{1 equivalent barytes} & 76\\ \text{10 equivalents water} & 90\end{array}\right\}\text{give}\left\{\begin{array}{l}45{\cdot}8\\ 54{\cdot}2\end{array}\right\}\text{in 100.}$$

$$\overline{166}$$

which agrees sufficiently well with my experiment to show that the crystals contain only 10 equivalents of water, instead of 20 as stated by Dr. Dalton.

According to Dr. Hope, the crystals of strontia contain 68 per cent. of water, and Dr. Dalton concludes from this statement that they contain 12 equivalents of it. I prepared some crystals of strontia in the same manner as those of barytes above described; they were dried in a similar mode, and taking the mean of two experiments, which differed but very little, 100 parts of the crystals, after saturation with muriatic acid and treatment with carbonate of ammonia, gave 51·57 of carbonate of strontia; and as 74 of this substance consist of 22 of carbonic acid and 52 base, 51·57 contain 36·24 of strontia, which, deducted from 100, the crystals experimented upon, leave 63·76 as the quantity of water contained in them. The crystals are therefore evidently composed of

$$\left.\begin{array}{lll}\text{1 equivalent of strontia} & 52, \text{ or } 36{\cdot}62\\ \text{10 equivalents of water} & 90, \text{ or } 63{\cdot}38\end{array}\right\}\text{in 100.}$$

$$\overline{142}$$

and resemble those of barytes with respect to the quantity of water which they contain.

VIII. *Reviews, and Notices respecting New Books.*

A Manual of Mineralogy, comprehending the more recent Discoveries in the Mineral Kingdom. By ROBERT ALLAN, *Esq., F.R.S.E., M.G.S.L., &c.* 1 vol. 8vo, London, 1834.

MINERALOGY, in its most limited sense, is that branch of Natural History which takes cognizance of the forms and external properties of mineral substances, with a view to their accurate discrimination and to their arrangement into groups or classes. Thus considered, it may perhaps be thought scarcely to aspire to the dignity of a science; but, by its connexions with other branches of human knowledge, it acquires a claim to higher distinction. All the materials of which our globe is composed, however complex in appearance, are resolvable into more simple minerals. In the older rocks, especially, we recognise, by the descriptions of the mineralogist, the proximate materials which compose and characterize those rocks; and hence Mineralogy has been regarded as the alphabet of Geology. The identification of the mass also often depends essentially on that of its component minerals.

Of late years Mineralogy has extended its alliances to other sciences. From examples taken from the mineral kingdom, Mitscherlich derived his first views of isomorphism; and by the optical properties of minerals formed in the laboratory of nature, Brewster and Herschel were led to the discovery of laws, that not only explain obscure phænomena, but furnish, in their turn, new instruments for investigating the structure and differences of mineral substances*. With Chemistry, also, the relations of mineralogy are constantly becoming closer and more numerous, each science rendering to the other the tribute of new facts and new principles.

It is time, however, to speak of the work before us. It is an unpretending volume, manifesting great diligence in the collection of its materials, and equal judgement in their arrangement. How much such a book was wanted, every British mineralogist must have sensibly felt. Since the publication of Mr. William Phillips's "Elementary Introduction to Mineralogy," (an excellent work for the time, and still valuable on many accounts,) eleven years have elapsed; and nine years have passed since that of Haidinger's Translation of Mohs's work. During that long interval, a vast number of new minerals have been discovered, the accounts of which can only be consulted by laborious search though the periodical records of science. To incorporate these with our previous knowledge was not, as it might be supposed, a work of mere labour. It was quite necessary that the compiler should himself be thoroughly versed in practical mineralogy, and qualified to correct and improve the descriptions of previous writers. In the preface, the author informs us that his descriptions have in most instances been carefully collated with specimens in the collection of his late father (well known to be almost unrivalled for its excellence); and the figures in outline of crystallized minerals have been carefully drawn by himself from the best examples in that cabinet †. The localities and modes of occurrence of minerals, which are numerous and correct, have been assigned from his own observations in the principal mining districts of this country and the Continent. In many instances he has noticed in what public and private cabinets the best specimens of the rare and most costly minerals may be consulted.

An "Introduction," prefixed to the volume, conveys elementary information in a manner well adapted to beginners in the science; and a copious index gives the reader access to the almost endless synonyms which have so greatly perplexed mineralogical language. We have no hesitation, then, in pronouncing Mr. Allan's work to be a safe guide for the student, and a valuable book of reference to the experienced mineralogist. *.*

* See Prof. Whewell's Report on Mineralogy, read at the Meeting of the British Association in 1832; and Sir John Herschel's Preliminary Discourse, part III. chap. iv.

† The collection has been publicly announced for sale by auction at Edinburgh about the middle of January. It is earnestly to be hoped that it may become the property of some public Institution, where, by being made accessible to men of science with the same liberality as by its late possessor, its utility may be extended and perpetuated.

IX. *Proceedings of Learned Societies.*

ROYAL SOCIETY.

[Continued from vol. v. p. 459.]

1834. June 19.—THE following Papers were read:

1. "Observations on the *Teredo navalis* and *Limnoria terebrans*, as at present existing in certain localities of the British Islands." By William Thompson, Esq., Vice-President of the Natural History Society of Belfast. Communicated by J. G. Children, Esq. Sec. R.S.

The opinion which has been advanced, that the *Teredo navalis* is no longer to be found on the British coast, is shown by the author to be erroneous; for numerous specimens of that destructive animal, collected from the piles used in the formation of the pier at Portpatrick in Ayrshire, were furnished to him by Captain Frayer, R.N. (of His Majesty's Steam-packet Spitfire). Some of these specimens had attained the length of nearly two feet and a half, a magnitude at least equal to, if not exceeding, the largest brought from the Indian seas. After giving a description of the animal, the author enters into an inquiry into the agency it employs to perforate the timber which it consumes as food, and in which it establishes its habitation. He ascribes to the action of a solvent, applied by the proboscis, the smooth and rounded termination of its cell, which is afterwards enlarged by the mechanical action of the primary valves.

The author then gives an account of the natural history and operations of another animal, the *Limnoria terebrans*, of Leach, belonging to the class of Crustacea, whose depredations on timber are no less extensive and formidable than the *Teredo*. At Portpatrick it appears that both these animals have combined their forces in the work of destruction, the *Teredo* consuming the interior, and the *Limnoria* the superficial parts of the wood; the latter continuing its labours until it comes in contact with the shells of the former, so that the whole mass is speedily deprived of cohesion. It is stated, on the authorities of Mr. Hyndman and Mr. Stephen, that the *Limnoria* is already committing great ravages in the timber at Donaghadee.

2. "On the Nervous System of the *Sphinx ligustri* (Linn.) during the latter Stages of its Pupa and its Imago States; and on the Means by which its Development is effected." By George Newport, Esq. Communicated by P. M. Roget, M.D., Sec. R.S.

In a paper formerly read to the Royal Society, and printed in the Philosophical Transactions*, the author has given a description of the anatomy of the nervous system of the *Sphinx ligustri* in its larva, and the earlier periods of its pupa, state; and he has since prosecuted the inquiry then commenced, following the changes of structure through the remaining stages, until the insect has arrived at its full development. He enters into minute details of all these changes, which vary considerably in the rapidity with which they take place at different periods, according as the vital powers are called into action by

* An abstract of Mr. Newport's former paper will be found in Lond. and Edinb. Phil. Mag., vol. i. p. 382.

external circumstances, or become exhausted by their efforts at effecting the growth or modifying the form of different parts. Thus the ganglia and nervous cords undergo great changes both in their form and situation, and also in their number, during the passage of the insect from the larva to the pupa state; and after these changes have been carried to a certain extent, they are suspended for several weeks, during which the insect remains in a state of hybernation; but at the expiration of this period the changes again proceed, and are continued uninterruptedly, till the insect attains its ultimate or perfect stage of development. The *Sphinx ligustri* remains in the pupa state during at least forty-two or forty-three weeks; thus affording ample opportunities of examining the whole progress of the changes which take place in the structure of different parts. The concentration of the nervous system, which was commenced in the larva, proceeds to a much greater extent while the insect is inclosed in the pupa, and is continued for a short time after it has assumed the imago state. The double origin and connexions of the nerves distributed to the wings are described, and a conjecture offered as to the object of this arrangement, which appears designed to establish a harmony of action between the wings, in those insects, especially, which are remarkable for velocity and power of flight; a different disposition being adopted in those which fly with less regularity or speed. The nerves of the organs of sense, as the antennæ, eyes, proboscis, and apparatus for manducation, are traced and minutely described, and a comparison instituted between them and the nerves which have similar offices in vertebrated animals. The author traces the origin and course of the nerve corresponding to the *pneumo-gastric*, or *par vagum*, and shows that it is distributed chiefly to the organs of digestion and the respiratory passages. He next describes the anterior lateral cephalic ganglia, which, from their position, might be regarded as auxiliary brains. The situation and course of another nervous tract, which from its extensive connexions and peculiar mode of distribution is considered as corresponding to the sympathetic system, are also traced. The author notices a set of nerves which, adopting the views of Sir Charles Bell, he considers as analogous to those which the latter has denominated the respiratory nerves of vertebrated animals; and among a great number of interesting observations, of which it is impossible to give any abridged account, one of the most remarkable is the discovery that the primary longitudinal nervous cords of insects consist of two tracts, the one situated over the other, corresponding to the two columns of which the spinal cord consists in vertebrated animals; the one appropriated to sensation, and the other to voluntary motion; the nerves from each of these tracts being variously combined, according to the purposes they are designed to fulfill. This important distinction, which was first traced in the nervous cords of the Lobster, was afterwards distinctly observed by the author in the *Scorpion* and the *Scolopendra*, and lastly, in several species of insects, as the *Gryllus viridissimus*, the *Carabus*, the *Papilio urticæ*, and the *Sphinx ligustri*. Numerous drawings of the parts described accompany the paper.

3. "Observations on the Torpedo, with an account of some additional experiments on its Electricity." By John Davy, M.D., F.R.S., Assistant Inspector of Army Hospitals.

The first part of this paper is occupied by an investigation of the circumstances attending the fœtal development of the Torpedo. In the first stage of embryonic growth which the author had an opportunity of observing, when the embryo was about seven tenths of an inch in length, it had neither fins nor electrical organs, nor any appearance of eyes; it exhibited short external branchial filaments, not yet carrying red blood; and there was a red spot in the situation of the heart, communicating by red vessels in the umbilical cord with the vascular part of the egg. There is no membrane investing the fœtus, as is the case with some species of *Squali*; nor any fluid in the uterine cavity; neither could the author find any urea or lithic acid in that cavity. By taking the mean of many observations, it appeared that the weight of the egg, before any appearance of the embryo, is 182 grs., and after its appearance, including the weight of the latter, 177 grs.; while the weight of the mature fish is about 479 grs.; showing an augmentation of more than double. Thus it differs remarkably, in this respect, from the fœtal chick, which at its full time weighs considerably less than the original yolk and white from which it is formed. No communication can be traced between the fœtus of the Torpedo and the parent, through the medium of any vascular or cellular structure; and the stomach of the former is always found empty. Hence the only apparent source of nourishment is absorption from the surface; and the author states his reasons for believing that the branchial filaments are the principal absorbing organs, the materials they receive being chiefly employed in the construction of the electrical organs, while those which enter into the composition of the body generally are absorbed by the general surface of the fœtus. The author is led, from his researches, to the conclusion that the mode of reproduction in the Torpedo is intermediate between the viviparous and the ovoviviparous.

In the second part of the paper, the author discusses the question as to the number of species of the genus Torpedo existing in the Mediterranean; and concludes that there are only two, viz. the *Ochiatella* and the *Tremola*.

4. "Appendix to a former Paper on Human Osteology*." By Walter Adam, M.D. Communicated by Dr. Prout, F.R.S.

This appendix contains linear representations of various dimensions of the bones of the human body, both male and female, with a view to facilitate the comparison of the human frame with that of other animals, and reduce it to definite laws. The author states that many of the rectilinear dimensions of human bones appear to be multiples of one unit, namely, the breadth of the cranium directly over the external passage of the ear; a dimension which he has found to be the most invariable in the body. No division of that dimension

* An abstract of Dr. Adam's former paper was given in Lond. and Edinb. Phil. Mag., vol. iii. p. 457.

was found by him to measure the other dimensions so accurately as that by seven, or its multiples. Of such seventh parts there appear to be twelve in the longitudinal extent of the back, and ninety-six in the height of the whole body.

5. "On the Repulsive Power of Heat." By the Rev. Baden Powell, M.A., F.R.S., Savilian Professor of Geometry in the University of Oxford.

The expansion of bodies by heat appearing to imply a mutual repulsion of their particles, it becomes a question whether such repulsive power may not be excited by it between particles or masses of matter, at sensible as well as insensible distances. After noticing the partial investigations of this question by Libri, Fresnel, Saigey, and Professor Forbes, the author describes the method he has employed with a view to its solution, and which consisted in applying heat to two lenses of glass, pressed together so as to exhibit the colours of thin plates; the variation of the tints furnishing exact indications of the most minute changes of distance between the surfaces, by whatever causes they may be produced. The conclusion he deduces from his experiments, conducted on this plan, is that the separation of the surfaces is of a different character, and is greater than can be accounted for by the mere change of figure produced by the heat; and is therefore in part to be ascribed to a real repulsive action between the surfaces of the glasses derived from the power of heat. He also found, on trying similar experiments with glass in contact with a metallic surface, that the results were considerably influenced by the radiating power of the latter; the effect being increased when this power was greater, and also by all other causes tending to the more rapid communication of heat. This is still more apparent when the coloured rings are formed in a thin plate of water interposed between the lenses, and where the effects are independent of radiation.

6. "Analysis of the Moira Brine Spring near Ashby-de-la-Zouch, Leicestershire, with Researches on the Extraction of Bromine." By Andrew Ure, M.D., F.R.S.*

The water derived from the spring in question is raised by means of a pump from the coal mines in the neighbourhood of Ashby-de-la-Zouch, is much used as medicinal baths, and is also administered internally, principally as a remedy for bronchocele and scrofulous tumors. The result of the analysis made by the author, is that it contains per gallon,

	grs.
Bromide of sodium and magnesium	8·
Chloride of calcium	851·2
——— magnesium	16·
——— sodium	3700·5
Protoxide of iron, a trace	
Solid contents	4575·7

* See an abstract of Prof. Daubeny's paper "On the occurrence of Iodine and Bromine in certain mineral waters of South Britain," in Phil. Mag. and Annals, N.S., vol. viii. pp. 61, 62.

After removing from the water the deliquescent chlorides of lime and magnesia by the addition of carbonate of soda, he transmits through the mother liquor, consisting of chloride and bromide of sodium, a current of chlorine gas, till it communicates the maximum golden tint, and then adds sulphuric æther, which, by agitation, carries with it to the surface the bromine and chlorine, constituting a reddish yellow stratum. The proportion in which these two elements exist in the evaporated solution may be ascertained with the greatest nicety by the addition of a solution of nitrate of silver; the method of calculation for this purpose being detailed by the author.

7. "On the Nature and Origin of the Aurora Borealis." By the Rev. George Fisher, M.A., F.R.S.

The author deduces from his own observations made during a residence of two winters in high northern latitudes, taken in conjunction with the concurring testimony of various navigators and travellers, the general fact that the Aurora Borealis is developed chiefly at the edge of the Frozen Sea, or wherever there is a vast accumulation of ice; and he conceives that it is produced in situations where the vapours of a humid atmosphere are undergoing rapid congelation. Under these circumstances, when viewed from a distance, it is seen fringing the upper border of the dark clouds, termed the "sea blink," which collect over these places; and it generally forms an arch a few degrees above the horizon, shooting out vertical columns of pale yellow light. He concludes that the Aurora Borealis is an electrical phenomenon, arising from the positive electricity of the atmosphere, developed by the rapid condensation of the vapour in the act of freezing, and the induced negative electricity of the surrounding portions of the atmosphere; and that it is the immediate consequence of the restoration of the electrical equilibrium by the intervention of the frozen particles, which being imperfect conductors, become luminous while transmitting this electricity. In tropical and temperate climates this phenomenon does not occur, because the electric equilibrium is restored by means of aqueous vapours, a process which often gives rise to thunder and lightning, but never to the Aurora Borealis; the latter being peculiar to clear, cold and dry weather.

8. "Théorie Balistique." Par M. Le Comte de Prédaval. Communicated by Dr. Roget, Sec. R.S.

The author inquires into the influence which he conceives the following circumstances may have on the path of a projectile on the surface of the earth; namely, first, the direction of the line of projection relatively to the meridian or cardinal points; secondly, the latitude of the place; and thirdly, the barometric conditions of the atmosphere.

9. "On the Atmospheric Tides and Meteorology of Dukhun, in the East Indies." By Lieut.-Colonel W. H. Sykes, F.R.S.

The author premises detailed descriptions of the various instruments used in the meteorological observations recorded in this paper, and of the methods employed in obtaining his results; of which the great features are the barometrical indications of diurnal and noc-

turnal atmospheric tides, embracing two maxima and two minima in the twenty-four hours. The following are the chief topics noticed in the paper, and the principal facts established by these inquiries: namely, 1. The removal of the doubts entertained by Humboldt, founded on the authority of Horsburgh, of the suspension of the atmospheric tides during the monsoon in Western India; the existence of the four atmospheric tides already mentioned, and their occurrence within the same limiting hours as in America and Europe; the greatest mean diurnal oscillations in Dukhun taking place in the coldest months, and the smallest in the damp months; whilst at Madras, the smallest oscillations are in the hottest months, and in Europe it is supposed that the smallest oscillations are in the coldest months. 2. The regular diurnal and nocturnal occurrence of the tides, without a single case of interversion, whatever may be the thermometric or hygrometric indications, or the state of the weather; storms and hurricanes only modifying, but not interrupting them. 3. The anomalous fact of the mean diurnal oscillations being greater at Poona, at an elevation of 1823 feet, than at the level of the sea, in a lower latitude, at Madras. 4. The fact of the diurnal tides, at a higher elevation than Poona, being less, whilst the nocturnal tides are greater than at Poona; and the seasons apparently not affecting the limiting hours of the tides. 5. The maximum mean pressure of the atmosphere being greatest in December and January; then gradually diminishing until July and August; and subsequently increasing to the coldest months. 6. The very trifling diurnal and annual oscillations compared with those of extra-tropical climates. 7. The annual range of the thermometer being less in Dukhun than in Europe, but the diurnal range much greater; the maximum mean temperature occurring in April and May, and gradually declining until December and January; and the observed mean temperature of places on the continent of India being much higher than the calculated mean temperature according to Mayer's formula. 8. The mean annual dew-point being higher at half-past nine o'clock than either at sunrise or at four in the afternoon; the dew-point being highest during the monsoons, and lowest during the cold months, and varying considerably within very short distances; being, for example, remarkably contrasted in Bombay and Dukhun; and the frequent occurrence of dew quite locally and under anomalous circumstances. 9. The amount of rain in Dukhun being only 20 per cent. of that falling in Bombay, 90 or 100 miles to the westward. 10. The wind being principally from the west and east, and rarely from the opposite quarters. 11. The great abundance of electricity under certain circumstances. 12. The rare occurrence of fogs. 13. The great amount of solar radiation; and lastly, the singular opacity of the atmosphere during hot weather, giving rise occasionally to the mirage. A variety of tables containing the records of meteorological observations, with instruments, accompany the paper.

10. "On the Ova of the *Ornithorhynchus paradoxus*." By Richard Owen, Esq. Communicated by W. Clift, Esq., F.R.S.

The author, in this paper, has prosecuted more immediately and more minutely than in his former communication*, the inquiry into the structure of the ovary of the Ornithorhynchus, with a view to determine its exact relations with that of the normal Mammalia, and of the oviparous Vertebrata. He has obtained from this investigation the full confirmation of the truth of the opinion he had previously formed, that lactation might coexist with a mode of generation essentially similar to that of the Viper and Salamander; and this fact has been further established by the subsequent examination which he has made of the uterine fœtus of the Kangaroo.

The author traces the regular gradation which obtains in different orders of Mammalia in which true viviparous or placental generation takes place, towards the ovo-viviparous or oviparous modes, in which the exterior covering of the ovum never becomes vascular, and shows that the Ornithorhynchus constitutes a connecting link in this chain.

Drawings illustrative of the anatomical descriptions of the parts examined by the author accompany the paper.

11. "Observations with the Horizontal and Dipping Needles, made during a Voyage from England to New South Wales." By James Dunlop, Esq. Communicated by Capt. Beaufort, R.N., F.R.S.

This paper contains a very numerous and uninterrupted series of magnetical observations, made in the circumstances stated in the title, and extending about 180 degrees in longitude and 100 degrees in latitude. The apparatus, of which a detailed description is given, was suspended from the roof of the cabin, and no alteration was made in its suspension from the beginning to the end of the voyage.

12. "Experiments on Light." By Henry Fox Talbot, Esq., M.P., F.R.S. This paper will be found in our last Volume, p. 321.

13. "On the Mummy Cloth of Egypt; with Observations on the Manufactures of the Ancients." By James Thomson, Esq., F.R.S. Communicated by Dr. Roget, Sec. R.S. This paper will also be found in our last Volume, p. 355.

14. "An Account of some Experiments to measure the Velocity of Electricity, and the Duration of Electric Light." By Charles Wheatstone, Esq., Professor of Experimental Philosophy in King's College, London. Communicated by Michael Faraday, Esq., F.R.S.†

The continuance for a certain time of all luminous impressions on the retina prevents our accurately perceiving, by direct observation, the duration of the light which occasions these impressions, but by giving the luminous body a rapid motion, which produces the appearance of a continued train of light along the path it has described, its condition at each moment may be ascertained, and consequently its duration determined. The same law of our sensations precludes us from direct perception of the velocity with which the luminous cause is

* An abstract of Mr. Owen's former communication was given in Lond. and Edinb. Phil. Mag., vol. i. p. 384. See also vol. ii. p. 71; vol. iii. pp. 62, 301; vol. iv. p. 54; and vol. v. pp. 145, 147, 235.

† See Lond. and Edinb. Phil. Mag., vol. iii. pp. 81, 204; and vol. iv. pp. 113, 114.

moving, as the whole of its track, for a certain distance, appears to be equally illuminated; but by combining a rapid transverse motion of the body from which the light proceeds, with that which it had before, its path may be lengthened to any assignable extent, and both its duration and its velocity will admit of measurement. The author gives various illustrations of this principle, and of his attempts to apply it to appreciate the duration and the velocity of the electric spark. His first experiments were made by revolving rapidly the electric apparatus giving electric sparks; but in every instance they appeared to be perfectly instantaneous. He next resorted to the more convenient plan of viewing the image of the spark reflected from a plane mirror, which, by means of a train of wheels, was kept in rapid rotation on a horizontal axis. The number of revolutions performed by the mirror was ascertained, by means of the sound of a siren connected with it, and still more successfully by that of an arm striking against a card, to be 800 in a second. The angular motion of the image being twice as great as that of the mirror, it was easy to compute the interval of time occupied by the light during its appearance in two successive points of its apparent path, when thus viewed; and it was ascertained that the image passed over half a degree (an angle which, being equal to about an inch, seen at a distance of ten feet, is easily detected by the eye,) in the 1,152,000th part of a second. The result of these experiments, as regarded the duration of the spark, was that it did not occupy even this minute portion of time; but when the electric discharge of a battery was made to pass through a copper wire of half a mile in length, interrupted both in the middle, and also at its two extremities, so as to present three sparks, they each gave a spectrum considerably elongated, and indicating a duration of the spark of the 24,000th part of a second. The sparks at both extremities of the circuit were perfectly simultaneous, both in their period of commencement and termination; but that which took place in the middle of the circuit, though of equal duration with the former, occurred later, by at least the millionth part of a second, indicating a velocity of transmission from the former point to the latter of nearly 288,000 miles in a second; a velocity which exceeds that of light itself.

The following letter was read from the Chair.

"British Museum, June 19th, 1834.

"My Dear Sir,—His Royal Highness the President requests that, when you adjourn the meeting this evening to the 20th of November, you will have the goodness to express his great regret that, unfortunately, the state of his health and sight has lately been such as to render it impossible for him to preside at the ordinary meetings of the Society so frequently as it was his anxious wish to have done. His Royal Highness begs you will assure the Society that his absence has been occasioned by the cause alluded to alone, and from no feeling of diminished interest in the prosperity of the Royal Society, or of regard and respect for the Fellows; on the contrary, His Royal Highness hopes that, by the blessing of Providence, his health will soon be in all respects so far re-established as to enable him, on the reassembling

of the Society, to resume the chair, and fill it with that uninterrupted regularity which it is His Royal Highness's most anxious wish to observe, in whatever duty he undertakes.

"Ever, my dear Sir, faithfully yours,
"JOHN GEORGE CHILDREN.

"P.S.—His Royal Highness requests you will in his name bid the Fellows heartily farewell till he meets them again in November."

"Francis Baily, Esq., V.P. R.S."

The Society then adjourned over the long vacation, to meet again on the 20th of November.

GEOLOGICAL SOCIETY.

November 19th.—A paper was first read, entitled "An Account of the raised Beach, near Hope's Nose, in Devonshire, and other recent Disturbances in that Neighbourhood," by Alfred Cloyne Austen, Esq., F.G.S.

The ancient beach near Hope's Nose, noticed by Mr. Greenough in his geological map, is situated a little within the point of land so called, and rests upon a mass of transition limestone containing thin beds of shells. The distance between the ordinary line of high water and the lowest part of the deposit, is about 31 feet: its extent east and west is not more than 50 feet; and its thickness is 17 feet. How far it extends inland cannot be easily determined, as it is covered, in that direction, by an accumulation of detritus fallen from the neighbouring hill.

The deposit varies much in texture and composition. The lowest portion is a coarse conglomerate, containing blocks of considerable size; above this the grain becomes finer and the organic remains, consisting of shells of recent species, occur in greatest abundance. A little higher the particles are still finer, forming an exceedingly hard and compact stone, in which frequently the casts only of the shells are found. In the upper portion the beds are less compact, and at the highest they consist of uncemented sand, like that of a recent beach. The greater part of the deposit is formed from grauwacke rocks, but fragments of trap also occur, and in the lowest part chalk flints. On the weathered surface, the harder beds project in thin shelves, but of sufficient strength to support a man.

A deposit which encircles the Thatcher rock, about three quarters of a mile S.S.W. of Hope's Nose, presents the same characters. These are the only instances which the author could discover of a raised beach on this part of the coast. The preservation of the deposits, he considers, is owing to their resting on masses of limestone, and that the abrupt terminations which the beach at Hope's Nose presents towards the east and west, are proofs that it was once more extensive.

Watcombe Fault.—The author premises his observations on the Watcombe fault by stating, that any section of the new red sandstone of South Devon will present innumerable lines of disturbance, and that attention to these will show they have been the origin of the hills and valleys of the district; though all superficial evidence of their existence has been destroyed by their being rounded off.

But in the neighbourhood of Babbacombe, he says, there are several faults which at first sight offer a very different character. Of these he mentions two, that at Watcombe and another west of Petit Tor rock. The first presents a vertical change of level of about 200 feet; but it is not, like the faults before alluded to, rounded off, and therefore the author infers that it is of more recent origin.

Some observations are then offered on the position of the trap in the neighbourhood of Babbacombe; and it is shown, that in the hill to the east of the town it rests on shale, and is overlaid by beds of shale and limestone, the trap dipping to the south-west conformably with the stratified deposits. At its lower surface it adheres firmly to the shale; but at its upper no such adhesion occurs, though the bed which rests upon the trap is moulded into its outline. From this phænomenon, and the absence of all marks of disturbance, the author infers, that the trap was a submarine lava current, on which the superincumbent limestone and shale were subsequently deposited. In other instances, however, as in the hill between Torquay and Tor Abbey, the limestone appears to have been violently disturbed, the beds of new red sandstone on the flanks of the hill being in a vertical position.

In conclusion the author offers some remarks on the drainage and destruction of the lake which he supposes to have occupied the site of the Ballemarsh and Bovey Heathfield.

A paper, entitled, "Some Facts in the Geology of the Central and Western Portions of North America, collected principally from the statements and unpublished notices of recent travellers," by Henry Darwin Rogers, Esq., F.G.S., was then begun.

December 3rd.—The reading of Mr. Rogers's paper was resumed and concluded.

Mr. Rogers states that he is indebted for the greater part of the facts contained in his communication to Mr. Sublette, a gentleman engaged for eleven years in the fur trade; but that he has also extracted from the journals of Long and Lewis, and Clerke and Nutthall, such observations as bear upon the structure of the country.

The district noticed includes the vast tract extending from the Mississippi to the Pacific, and from the 36th to the 49th degree of North latitude. The principal physical features of the country are the Rocky Mountains; and the immense plains which extend from the Mississippi to that range, circle round its southern termination, and are prolonged into Mexico, and northward to an unknown distance.

The Rocky Mountains consist, as far as they have been examined, of primary formations, and their eastern chain, the Black Hills, of gneiss and mica slate, greenstone, amygdaloid, and other igneous rocks. Chains of primary mountains, separated by sandy plains and volcanic tracts, constitute the country between the Rocky Mountains and the Pacific; but to the east of that range are several nearly horizontal formations, of the limits or the relative age of which little is known.

The country from the falls of the Platte to the mountains, and from the Missouri to the Arkansas and the Rio Colorado, as well as the plains included within the Rocky Mountains, is composed of

a red saliferous sandstone, containing beds of clay; and Mr. Rogers is of opinion that the same formation extends into Mexico, and that the red sandstone described by Humboldt as occurring extensively in the southern parts of the continent, may belong to it. The general colour of the sandstone is red, but it is sometimes gray or white. The saline contents are principally muriate of soda, but other salts of bitter and cathartic properties likewise abound. Brine springs are of general occurrence; and rock-salt is found in large beds west of the Rocky Mountains, as well as on the Rio Colorado, and south of the great Salt Lake. The surface of the ground, especially of the banks of the ravines, is often also thickly encrusted with saline matter. Gypsum is likewise found in many parts of the country. Fossils are said to abound in the sandstone on the river Platte, but Mr. Rogers states that he had not seen any of them. In the neighbourhood of the Rocky Mountains the formation is covered with a deposit of gravel and boulders, apparently derived from the adjacent hills; but at a distance from them it is overlaid by a bed of loose barren sand, the drifting of which Mr. Rogers conceives may partially conceal the existence of other formations, especially of that greensand which occurs so extensively on the Missouri above the river Platte.

At the eastern base of the Rocky Mountains and for a short distance up their declivity, are various conglomerates and gray and red sandstones, dipping at high angles; but the author conceives that these deposits do not belong to the great sandstone formation, as they contain no salt.

In ascending the Missouri from its confluence with the Mississippi the banks are in many places composed of limestone cliffs, 200 and 300 feet high, containing Productæ, Terebratulæ, and Encrini: hills of this limestone occur also near the Chariton; and in the same district is good bituminous coal.

Above the junction of the Platte with the Missouri are beds of sandstone and dark blue shale, and a little higher, adjacent to the Au Jacque, are high, perpendicular bluffs of a formation considered to be true chalk. This deposit extends for several miles up the Missouri, and it occurs further down the river about the mouth of the Omawhaw; but its lateral extent is not known. No flints have yet been noticed *in situ*, but pebbles and nodules of flints, similar to those so abundant in the valley of the Thames, are numerous lower down the river, even as low as the Mississippi. Mr. Rogers likewise states that he had seen Belemnites reported to have been picked up in the same district.

From below the Big Bend to the Rocky Mountains, both on the Missouri and the Yellow-stone river, is a vast formation, said to be very rich in fossils, indicating an upper secondary group; and Mr. Rogers observes that the matrix in which the shells are imbedded resembles very closely some of the greensand-beds of Europe. The fossils mentioned in the paper are a Hamite, a Gryphæa considered to be the *Gryphæa Columba*, and *Belemnites compressus*. This formation has not been traced continuously over the whole area

alluded to, but the same fossils have been brought from beds of the Missouri and Yellow-stone rivers, as well as from their springs in the Rocky Mountains; and they have been found west of that range.

Above the Big Bend occurs also an extensive range of horizontal beds of lignite, sandstone, shale, and clay, forming bluffs 200 and 300 feet high, and continuous for several days' journey. Lignite is also found on the Cherry River, and along the whole of the country watered by the Powder River, in beds from 3 to 9 feet thick. This formation Mr. Rogers conceives to be more recent than that which contains the fossils, as the latter has a slight westerly dip, and therefore may underlie it.

Silicified trunks of trees are stated to have been noticed on the banks of the streams, and are considered by the hunters to have fallen from the bluffs.

No recent volcanic production appears to have been yet brought from the country east of the Rocky Mountains, with the exception of the pumice which annually descends the Missouri; but nothing is yet known of the quarter whence it is derived. West of the mountains, however, from the Salmon River to beyond Louis's River, and for a considerable distance around the insulated mountains called the Butts, the country is said to be composed of lava traversed by a multitude of deep, extensive fissures, having a general direction from north-west to south-east, and nearly parallel to that of the mountains.

Volcanic mounds, cracked at the top and surrounded by fissures, are numerous over the whole region; but no lava appears to have flown from them, and Mr. Rogers conjectures that they were formed by the action of elastic or gaseous matter. In many places deep circular funnels, a few yards in diameter, penetrate the surface. For more than 40 miles the Columbia runs between perpendicular cliffs of lava and obsidian, from 200 to 300 feet high, which are traversed by great fissures, and present all the phænomena of dykes in the most striking manner. The Malador branch of the Columbia flows through a similar gorge.

In the course of the memoir Mr. Rogers corrects the account previously given of the great salt lake, which, he says, Mr. Sublette journied round, and ascertained to have no outlet, though it receives two considerable streams of fresh water. The length of the lake is estimated to be 150 miles and its breadth 40 or 50.

In conclusion, some observations are offered on the thermal springs which abound along the base on each side of the Rocky Mountains, and in the volcanic district. They are stated to vary in temperature from blood-heat to the boiling-point; and to form, from their earthy contents, large mounds, sometimes of a pure white, hard, siliceous nature, and at others of a substance which on drying becomes pulverulent. In the volcanic district some of the springs are said to be sour; and many sulphureous springs occur both in and west of the mountains. Lastly, pure sulphur has been occasionally seen above the Great Salt Lake, and at the eastern base of the mountains, but none in the volcanic district.

A letter was then read from H. T. De la Beche, Esq., F.G.S., and addressed to the President, on the Anthracite found near Biddeford in North Devon.

Mr. De la Beche says, the anthracite occurs along a strip of country about thirteen miles in length from east to west and about three quarters of a mile in breadth from north to south. It commences eastward at Hawkridge Woods on the banks of the Taw, and extends westward to Greencliff in Biddeford Bay, where the sea cuts off all further observation of its course in that direction. On the opposite side of the bay, however, a very carbonaceous slate is found in the cliffs among the greatly contorted strata of grauwacké between Clovelly and Hartland Point. There can be little doubt, Mr. De la Beche observes, that this carbonaceous slate belongs to the same system as the Biddeford beds, and thus it would be extended about eleven miles still further westward, where the sea again cuts it off. The anthracite between Hawkridge and Greencliff has been extensively worked at various times, and at the latter place is now worked for the sole supply of a limekiln. The beds of anthracite do not occur precisely in the same line with each other, so that one or two beds are not so far continuous, but swell out in particular places, the maximum thickness not exceeding 12 feet.

The letter was accompanied by a collection of fossil plants, all collected by Mr. De la Beche; and he says there can be no question that the shales, slates, sandstones, and anthracite, among which they are found, belong to the grauwacké, the evidence being of the most clear and satisfactory kind*.

With regard to the position of these beds in the grauwacké of Devon generally, it may be considered at about two thirds of the whole, above that part where the grauwacké shades away into the mica slate, chlorite slate, and other non-fossiliferous rocks of the most southern part of Devon. It should, however, be observed that the grauwacké of Devon and Somerset is not complete, and that we nowhere can see what can be decidedly termed its upper portions. After very diligent search, Mr. De la Beche observes, he has been unable to discover any of the interesting beds of the upper grauwacké noticed by Mr. Murchison in Wales or the adjoining English counties. On the north coast of Devon and its continuation into Somersetshire, precisely where some traces of them should be expected, older beds are brought up by contortion (Dunkeny Beacon), and the other high land of the coast is formed of beds apparently of the same age with those which extend from Hartland to the eastward, a great trough being formed, supporting a body of

* The plants have been examined by Prof. Lindley, and he has decided that they are, as far as they can be determined, plants of the coal measures, viz. *Pecopteris lonchitica, Sphenopteris latifolia, Calamites cannæformis, Asterophyllites* resembling *A. longifolia*, another species, which may be *A. galioidis, Cyperites bicarinata*, and *Lepidophyllum intermedium*; also fragments apparently of Palm leaves, specimens of which Prof. Lindley states he has received from Bolton. The most abundant plant was too imperfect for its characters to be determined.

grauwacké, the chief portion of which is an argillaceous slate, calcareous matter being disseminated in the lowest portion of it, often in sufficient abundance to constitute limestone.

A paper was afterwards commenced on the physical and geological structure of the country to the west of the dividing range between Hunter's River (lat. 32° south) and Moreton Bay (lat. 27° south), with observations on the geology of Moreton Bay and Brisbane River, New South Wales, by Allan Cunningham, Esq., and communicated by William Henry Fitton, M.D., F.G.S.

ZOOLOGICAL SOCIETY.

[Continued from vol. v. p. 385.]

August 12.—A Letter was read, addressed to the Secretary by B. H. Hodgson, Esq., Corr. Memb. Z. S., and dated Nepâl, February 28, 1834. It related chiefly to the distinguishing characteristics between the *Ghŏrăl* and the *Thâr Antelopes,* and an abstract of it is published in the Proceedings.

The exhibition was resumed of the new species of *Shells* contained in the collection formed by Mr. Cuming on the Western Coast of South America, and among the Islands of the South Pacific Ocean. Those exhibited on the present evening consisted of various species of *Anatinidæ* and of the *Myidous* genus *Saxicava*: they were accompanied by characters by Mr. G. B. Sowerby, and were named as follows:

PERIPLOMA *lenticularis,* and *planiuscula*; ANATINA *prismatica,* and *costata*; LYONSIA *picta,* and *brevifrons*; SAXICAVA *tenuis purpurascens,* and *solida.*

A collection of *land* and *fresh-water Shells,* formed in the Gangetic Provinces of India by W. H. Benson, Esq., of the Bengal Civil Service, and presented by that gentleman to the Society, was exhibited. It comprised forty species, and was accompanied by a descriptive list prepared by the donor, and also by detailed notices of some of the more interesting among them. These notices were read: they are intended by Mr. Benson for publication in the forthcoming No. of the ' Zoological Journal.'

From the time that he first became acquainted with the animal of a *Shell* resembling in all respects, except in its superior size, the European *Helix lucida,* Drap., Mr. Benson regarded it as the type of a new genus of *Helicidæ* intermediate between *Stenopus,* Guild., and *Helicolimax,* Fér. He had prepared a paper on this genus, for which he intended to propose the name of *Tanychlamys*; he finds, however, that Mr. Gray has recently described (Lond. and Edin. Phil. Mag. vol. v. p. 379.) the same genus under the name of *Nanina.* The generic characters observed by Mr. Benson are as follows:

NANINA, *Gray.*

Testa heliciformis, umbilicata; peritremate acuto, non reflexo.

Animal cito repens. Corpus reticulosum, elongatum. Pallium amplum, foramine communi magno perforatum, peritrema amplexans; processubus duobus transversè rugosis (quasi articulatis) omni latere mobilibus instructum, unico prope testæ aperturæ angulum superiorem exoriente, altero apud peripheriam testæ.

Os anticum inter tentacula inferiora hians; labia radiato-plicata. Tentacula superiora elongata, punctum percipiens tumore oblongo situm gerentia. Penis prægrandis; antrum cervicis elongatum latere dextro et prope tentacula situm. Solea complanata pedis latera æquans. Cauda tentaculata; tentaculum subretractile, glandulâ ad basin positâ humorem viscidum (animale attrectato) exsudante.

Mr. Benson describes particularly the habits of the species observed by him, which he first discovered living at Banda in Bundelkund on the prone surface of a rock. The animal carries the shell horizontally or nearly so; is quick in its motions; and, like *Helicolimax*, it crawls the faster when disturbed, instead of retracting its *tentacula* like the *Snails* in general. In damp weather it is rarely retracted within its shell, the foot being so much swelled by the absorption of moisture that if it is suddenly thrown into boiling water the attempt to withdraw into the shell invariably causes a fracture of the aperture. In dry weather the foot is retracted, and the aperture is then covered by a whitish false *operculum* similar to that of other *Helicidæ*. The two elongated processes of the mantle are continually in motion, and exude a liquor which lubricates the shell, supplying, apparently, that fine gloss which is observable in all recent specimens. The fluid poured out from the orifice at the base of the caudal horn-like appendage is of a greenish colour; it exudes when the animal is irritated, and at such times the caudal appendage is directed towards the exciting object in such a manner as to give to the animal a threatening aspect.

Of several specimens brought to England by Mr. Benson in 1832, one survived from December 1831, when it was captured in India, until the summer of 1833.

Another *Shell* particularly noticed by Mr. Benson is the type of a new genus, allied to *Cyclostoma*, which he has described under the name of *Pterocyclos* in the first No. of the 'Journal of the Asiatic Society of Calcutta.'

Specimens of a species of *Assiminia*, Leach, were preserved alive in a glass, replenished occasionally with fresh or salt water, until after the vessel in which Mr. Benson returned to England had passed St. Helena.

A *Snail* obtained near Sicrigali and the river Jellinghy, one of the mouths of the Ganges, is characterized by Mr. Benson as Helix *interrupta*.

In the character of the excrement being voided from an opening in the terminal and posterior part of the foot instead of from the *foramen commune*, the animal of *Hel. interrupta* differs most materially from the other *Helices*. The angulated periphery of the shell shows an approach to *Carocolla*, but Mr. Benson is not aware that the animal of this genus differs from that of *Helix*. From *Hel. Himalayana*, Lea, the *Hel. interrupta* is distinguished by its peculiar sculpture; its spire is also more exserted.

The collection also contained specimens of an *Arcaceous Shell* found in the bed of the Jumna at Humeerpore in Bundelkund. Mr. Benson proposes for it the generic appellation *Scaphula*.

Referring to specimens contained in the collection of a new form of *Solenaceous Shell*, described by him in the 'Journal of the Asiatic Society of Calcutta,' under the name of *Novaculina*, Mr. Benson describes also a second species of the genus which he has recently obtained from South America, and points out the characters which distinguish it from *Nov. Gangetica*.

The following Note by Mr. Benson relative to the importation of the living *Cerithium Telescopium*, Brug., adverted to at the Meeting on March 25, 1834, (vol. v. p. 145,) was read.

"The possibility of importing from other countries, and especially from the warmer latitudes, the animals which construct the innumerable testaceous productions that adorn our cabinets and museums, the accurate knowledge of which is so necessary to enable the conchologist rightly to arrange this beautiful department of nature, must be an interesting subject to every naturalist, and will render no apology necessary for the following notices extracted from my journal. Their publicity may incite others who may have opportunities of trying the experiment to follow the example.

"January 1832. Observed near the banks of the canal leading from the eastern suburb of Calcutta to the Salt Lake at Balliaghát, heaps of a *Cardita* with longitudinal ribs, of a large and thick *Cyrena*, and of *Cerithium Telescopium*, exposed to the heat of the sun for the purpose of effecting the death and decay of the included animals previously to the reduction of the shells into lime.

"Early in the month I took specimens of them, and leaving them for a night in fresh water I was surprised to find two *Cerithia* alive. I kept them during a fortnight in fresh water, and on the 22nd January carried them, packed up in cotton, on board a vessel bound for England. After we had been several days at sea I placed them in a large open glass with salt water, in which they appeared unusually lively. I kept them thus, changing the water at intervals, until the 29th May, when we reached the English Channel. I then packed them up, as before, in a box, and carried them from Portsmouth to Cornwall, and thence to Dublin, which I did not reach until the 14th June; here they again got fresh supplies of sea water at intervals. One of them died during a temporary absence between the 30th June and 7th July; and on the 11th July the survivor was again committed to its prison, and was taken to Cornwall and thence to London, where it was delivered alive to Mr. G. B. Sowerby on the 23rd July.

"This animal had thus travelled, during a period of six months, over a vast extent of the surface of the globe, and had for a considerable portion of that time been unavoidably deprived of its native element."—W. H. B.

At the request of the Chairman, Mr. Heming exhibited a *Swift*, *Cypselus Apus*, Ill., preserved in spirit, and showing a considerable dilatation at the base of the lower jaw and upper part of the throat. White has observed that "*Swifts*, when wantonly and cruelly shot while they have young, discover a lump of insects in their mouths, which they pouch and hold under their tongue;"

but from this notice it would scarcely have been anticipated that so large a collection was made as was found in the present instance. The dilatation had a rounded appearance; distended the skin so as to show distinctly and widely separated the insertion of each of the small feathers at this part; and measured in length 11 lines, and in depth 6. On opening the pouch it proved to be simple, and unconnected except with the cavity of the mouth.

Mr. Heming also exhibited a drawing taken from the recent bird.

Dr. Marshall Hall showed some experiments in the decapitated *Turtle*. Irritation of the nostrils, *larynx*, and spinal marrow induced acts of inspiration; that of the fins and tail induced movements of the other parts respectively.

But the principal object of Dr. Hall was to show that irritation of the nerves themselves equally induced movements of the limbs, &c. When either the sentient or the motory branch of the lateral spinal nerves was stimulated, motions were induced in all the limbs. Dr. Hall stated that a movement of inspiration and of deglutition was caused in the *Donkey* by irritation of the eighth pair of nerves. It has been already stated that irritation of the nostrils, or the branches of the fifth pair of nerves, induced inspiratory acts in the *Turtle*. From these and other facts, Dr. Hall is induced to consider the functions of these two nerves as similar. He further observed that both are nerves of secretion, and that both are muscular nerves —if the minor portion of the fifth be included—as well as exciters of respiration: the fifth differs chiefly in being sentient, being distributed to external as well as internal surfaces. With the fifth and eighth, Dr. Hall associates other spinal nerves. He considers respiration as a part of a general function of the nervous system, which presides over the *larynx*, *pharynx*, sphincters, ejaculators, &c., to which he has given the name of reflex, from its consisting of impressions carried to and from the *medulla oblongata* and *medulla spinalis*. Some illustrations of this function were given by Dr. Hall at the Meeting of the Committee of Science and Correspondence on November 27, 1832, (Lond. and Edinb. Phil. Mag. vol. ii. p. 477,) and further illustrations of it have formed the subject of a Paper by him, which has since been published in the 'Philosophical Transactions'. The experiments shown on the present occasion demonstrate the existence of a series of physiological facts at variance with the law laid down by M. Müller in his Paper entitled "Nouvelles Expériences sur l'effet que produit l'Irritation mécanique et galvanique sur les racines des nerfs spinaux; par Jean Müller, Professeur à l'Université de Bonn," and published in the 'Annales des Sciences Naturelles,' tom. xxiii. (1831), p. 95, viz. "Il suit encore qu'il y a des nerfs qui n'ont point de force *motrice* ou *tonique*, qui ne peuvent jamais occasionner des mouvemens par eux-mêmes, qu'ils soient irrités par l'action galvanique ou mécanique, et qui ne conduisent le courant galvanique que passivement, comme toutes les parties molles humides; qu'il y a en revanche des *nerfs moteurs* ou *toniques* (*nervi motorii seu tonici*) qui montrent à chaque irritation médiate ou immédiate leur force tonique, *qui agit toujours dans la direction des*

branches des nerfs et qui n'agit jamais en arrière." In Dr. Hall's experiments the influence first pursued a backward course to the spinal marrow, being afterwards reflected upon the muscles.

Dr. Hall next observed, in regard to respiration, that, whilst Sir Charles Bell is contending that it is involuntary, and Mr. Mayo that it is voluntary, the old doctrine of its being mixed, or partaking of both properties, is the true one. He founded this view upon the following facts:

1. If the *cerebrum* be removed, respiration continues as an involuntary function through the agency of the eighth pair of nerves;

2. If the eighth pair be divided, respiration equally continues, but as an act of volition; but

3. If the *cerebrum* be first removed, and the eighth pair be then divided, respiration ceases on the instant. Volition is first removed with the *cerebrum*; the influence of the eighth pair is then removed by its division. The two sources of the mixed or double function being both cut off, the function ceases.

Dr. Hall explains and reconciles in this manner the difficult and apparently contradictory facts,—that the *medulla oblongata* alone, above the origin of the eighth pair of nerves, or the eighth pair of nerves themselves, may be divided, without arresting the respiration; but that the *medulla oblongata* cannot be divided at the origin of these nerves without arresting the respiration instantly. In the first case the agency of volition is alone removed, and the respiration continues through the influence of the eighth pair; in the second, that of the eighth pair is removed, and the respiration continues as a function of volition; but in the third, both influences are destroyed at once, and with them the mixed or double function.

The same mixed or double character belongs to the other parts of the reflex function, as that of the *larynx*, the sphincters, the ejaculators. All the organs of the reflex function are also alike impressed through the medium of the mental affections or passions.

The course of the influence which constitutes the reflex function must be divided into the incident, or that into the *medulla*, and the reflected, or that from the *medulla*. The nerves which conduct the incident impression have, hitherto, received no designation; the others constitute a part of the system of muscular nerves. To the former class belong nerves which doubtless supply the *larynx* with its impressibility by carbonic acid, &c., &c., and hitherto undescribed, untraced; to the latter, the superior and inferior laryngeals: to the former belong the fifth, in the nostrils, in the face,—the eighth in the lungs, &c.; to the latter, the respiratory nerves: to the former, nerves hitherto undescribed of the sphincters, ejaculators, &c.; to the latter, the muscular nerves supplying these parts.

The whole constitutes the subject of an investigation in which Dr. Hall has been for some time engaged.

LINNÆAN SOCIETY.

Nov. 4.—Read descriptions of some additional species of the Dipterous genus Diopsis, by John O. Westwood, Esq., F.L.S.; and

the commencement of a paper on the Nervous System of the Mollusca and Radiata, by Robert Garner.

Nov. 18.—A continuation of Mr. Garner's paper on the Nervous System of the Radiated and Molluscous Animals was read.

Dec. 2.—A paper was read on a new Arachnide, uniting the genera Goryleptes and Phalangium, by the Rev. F. W. Hope, M.A., F.L.S. This insect, which is remarkable for the great disproportionate length of its hinder legs, forms a new genus, which Mr. Hope has named *Dolichoscelis*, and the species he has named *Haworthii*, in honour of the late Mr. Haworth, in whose collection the specimen had long been. It is a native of Brazil.

Read also part of a paper, entitled, "Descriptions of the Insects collected by Capt. P. P. King, R.N., F.R.S. & L.S. in his Survey of the Straits of Magellan." By John Curtis, Esq., F.L.S.; A. H. Haliday, Esq., M.A.; and Francis Walker, Esq., F.L.S.

Dec. 16.—The conclusion of Mr. Garner's paper was read.

CAMBRIDGE PHILOSOPHICAL SOCIETY.

The Anniversary Meeting was held on November the 6th, for the election of officers, when the following gentlemen were elected for the ensuing year:

President:—Joshua King, Esq., President of Queen's Coll., (re-elected).—*Vice-Presidents:* Dr. Clark, Trinity, (re-elected); Prof. Airy, Trinity, (re-elected); Prof. Miller, St. John's, (re-elected).—*Treasurer:* Rev. G. Peacock, Trinity.—*Secretaries:* Rev. W. Whewell, Trinity, (re-elected); Rev. J. S. Henslow, St. John's, (re-elected); Rev. J. Lodge, Magdalen Coll., (re-elected.)—*Old Council:* Rev. R. Willis, Caius Coll.; Dr. Bond, C. C. C.; Rev. J. Bowstead, C. C. C.; W. Hopkins, Esq., Pet. Coll.; Rev. T. Chevallier, Cath. Hall; Rev. J. Hymers, St. John's.—*New Council*: Prof. Sedgwick, Trinity; Dr. Haviland, St. John's; Rev. J. J. Smith, Caius Coll.; Rev. S. Earnshaw, St. John's.

Nov. 10.—Professor Airy, V.P., in the Chair. Many presents were produced and noticed, among which was the magnificent volume of the experiments of Col. Beaufoy, printed for private distribution by his son; and the Cambridge Observations for 1833, which now include regular observations with the mural circle as well as with the transit instrument. Several specimens of Fish, sent from Madeira by Mr. Lowe, were also presented; and a paper by him was read, containing a description of six new or very rare species. Mr. Whewell gave an account of the Tide Observations made at the Coast Guard Stations of the British Isles, from June 7 to June 22, of the present year; he also stated the mode in which he was discussing the observations, and the results to which they seemed likely to lead.

Nov. 24.—Prof. Airy, V.P., in the Chair. Prof. Airy gave an account of the calculations which he had caused to be made in order to determine the apparent disk of a star, and the rings which surround it, when seen through an object-glass with a circular aper-

ture. He also stated that corrections had recently been discovered to be necessary in the results of the Trigonometrical Survey of this county, by which the differences which had previously appeared to exist between the astronomical and geodetical determinations of the latitude and longitude of Cambridge Observatory are greatly diminished. Mr. Stevenson, of Trinity College, read a memoir on the establishment of the formulæ of Analytical Geometry by the combination of the infinitesimal method with the doctrine of projections. Prof. Sedgwick and other members then communicated some observations illustrative of the geology of Cambridge. The upper chalk with flints runs in a distinct terrace from near Newmarket, by Balsham and Linton, to Royston Downs, and thence into Hertfordshire. Beneath this is the lower chalk without flints, which runs from Reach to Cherryhinton and Haslingfield. Below this is a thin bed, which represents the upper greensand, and which, though not above a foot and a half thick, is remarkably continuous in the neighbourhood of Cambridge, being found at the Castle Hill, Barnwell, Ditton, Coton, and Modingley. Under this are the blue galt and the "lower greensand" of geologists, which may here be called the red-sand. The red-sand runs from Gamlingay and Caxton, by Conington, Longstanton, Cottenham, and Upware. But the junction of the galt and red-sand is covered up on the west of Cambridge by a large diluvial patch of "brown clay," which is full of rounded nodules of chalk. This brown clay forms an upland, which extends from Bourne, by Toft and Hardwicke, to Dry Drayton, after which it soon drops into the plain; but the junction of the strata in the plain is still covered up with ferruginous gravel as at Okington. Below the red-sand occur other clays, easily confounded with the galt, but identified with the Kimmeridge and Oxford clays by their fossils; these are found at Gransden, Cottenham Fen, and Ely. It was stated that the relations of the successive formations are very obscurely exhibited, in consequence of the strata and their junctions being masked by diluvial masses.

Dec. 8.—Prof. Airy, V.P., in the chair. Prof. Miller read a memoir on the position of the Optical Axes of Crystals. Prof. Henslow noticed some newly observed localities of the (upper) green-sand in the neighbourhood of Barton and Haslingfield. He then made some remarks on De Candolle's rules for determining the age of trees, and mentioned some instances which he had noticed during the preceding summer, in which they did not apply in the case of the yew. He conceived that these rules, when applied to several well known yew-trees in Britain, must give the age considerably too great. Prof. Airy mentioned the echo which is returned by the *open* end of the tall chimney recently erected at Barnwell gas-works. Prof. Cumming then gave a statement of Melloni's discoveries on the transmission of heat by radiation through glass and crystallized bodies, illustrated by apparatus and experiments.

X. *Intelligence and Miscellaneous Articles.*

ROYAL MEDALS TO BE AWARDED BY THE COUNCIL OF THE ROYAL SOCIETY, FOR THE MOST IMPORTANT DISCOVERIES AND INVESTIGATIONS IN SCIENCE, IN THE YEARS 1836 AND 1837.

IN order to perform our part in giving publicity to the determinations and intentions of the Council of the Royal Society with respect to the Royal Medals, we extract the following notice from the second part of the Philosophical Transactions for 1834, which has just appeared.

" *Royal Medals.*—His Majesty King William the Fourth, in restoring the Foundation of the Royal Medals, graciously commanded a letter, of which the following is an extract, to be addressed to the Royal Society, through His Royal Highness the Duke of Sussex, K.G., President:

" 'Windsor Castle, March 25, 1833.

" 'It is His Majesty's wish,—

" 'First, That the Two Gold Medals, value of Fifty Guineas, shall henceforth be awarded on the day of the Anniversary Meeting of the Royal Society, on each ensuing year, for the most important discoveries in any one principal subject or branch of knowledge.

" 'Secondly, That the subject matter of inquiry shall be previously settled and propounded by the Council of the Royal Society, three years preceding the day of such award.

" 'Thirdly, That literary men of all nations shall be invited to afford the aid of their talents and research: and,

" 'Fourthly, That for the ensuing three successive years, the said Two Medals shall be awarded to such important discoveries, or series of investigations, as shall be sufficiently established, or completed to the satisfaction of the Council, within the last five years of the days of award, for the years 1834 and 1835, including the present year, and for which the author shall not have previously received an honorary reward." '

" (Signed) 'H. TAYLOR.'

" The Council propose to give one of the Royal Medals in the year 1836, to the most important unpublished paper in astronomy, communicated to the Royal Society for insertion in their Transactions, after the present date and prior to the month of June in the year 1836.

" The Council also propose to give one of the Royal Medals in the year 1836 to the most important unpublished paper in Animal Physiology, communicated to the Royal Society for insertion in their Transactions, after the present date and prior to the month of June in the year 1836.

" The Royal Medals for the year 1833 were awarded to Sir John Frederick William Herschel, K.H., F.R.S., for his paper on the Investigation of the Orbits of Revolving Double Stars; and to Professor Auguste Pyrame De Candolle, of Geneva, Foreign Member

of the Royal Society, for his Discoveries and Investigations in Vegetable Physiology.

"Those for 1834 were awarded to John William Lubbock, Esq., V.P. and Treas. R.S., for his Papers on the Tides published in the Philosophical Transactions; and to Charles Lyell, Esq., for his Work entitled 'Principles of Geology.'

"The Council propose to give one of the Royal Medals in the year 1837 to the most important unpublished paper in Physics, communicated to the Royal Society for insertion in their Transactions, after the present date and prior to the month of June in that year.

"The Council also propose to give one of the Royal Medals in the year 1837 to the author of the best paper, to be entitled 'Contributions towards a System of Geological Chronology founded on an examination of fossil remains, and their attendant phænomena,' such paper to be communicated to the Royal Society after the present date and prior to the month of June 1837."

ON THE OCCURRENCE OF FRAGMENTS OF GARNET IN THE MILLSTONE-GRIT. BY W. C. TREVELYAN, ESQ.

To the Editors of the Philosophical Magazine and Journal of Science.

Gentlemen,

About the year 1826, I found dispersed rather abundantly in parts of the millstone-grit rock of Shaftoe in this neighbourhood, small, angular, transparent fragments of garnet: since that time I have met with them in similar rocks of the coal-fields near Kirkstall in Yorkshire, and Stirling in Scotland, and think that on further examination they may be more extensively observed, as it is probable that these rocks have been formed from the detritus of others, which are known sometimes to contain garnets in great abundance, as well as the other parts of which the millstone-grit is composed, among which I have also occasionally found small rolled fragments of hornblende.

I shall be glad if you think this notice worth printing in your Journal, for the purpose of drawing the attention of geologists to the subject: And remain, Gentlemen,

Your most obedient,

W. C. Trevelyan.

Wallington, Newcastle-on-Tyne,
29th September.

MINERALOGICAL NOTICES. BY H. J. BROOKE, ESQ. F.R.S. &C.

To the Editors of the Philosophical Magazine and Journal of Science.

Gentlemen,

I shall be obliged by your inserting the following mineralogical notices in the next Number of your Journal.

Gentlemen, yours, &c.

H. J. Brooke.

I have stated in the Philosophical Magazine and Annals, N.S. vol. x. p. 190, that *zurlite* and wollastonite are the same substance, a mistake into which I was led by having observed several speci-

mens of wollastonite ticketed *zurlite.* I have lately been favoured by Mr. Monticelli with specimens of *zurlite*, a *green* mineral, and bearing no resemblance to wollastonite, or to any specimen I have before observed.

The late Mr. Phillips, in his Elements of Mineralogy, gave a figure of a supposed crystal of the *flexible silver* of Bournon, differing altogether from Bournon's figures. The specimen from which that crystal was taken was said to be Bournon's mineral; it is, however, sulphuret of silver, and the figure given by Mr. Phillips is evidently a distorted modified cube. I have lately obtained a specimen of Bournon's flexible silver, so named by himself, from which it appears to be the same mineral as the *sternbergite* of Haidinger.

Mr. Phillips also gave a figure of *white tellurium* from a crystal he received from me. It is not, however, certain that this crystal is the mineral commonly so named. It is very minute and brilliant, and silver white, and there are many similar to it in the cavities of a small group, in my possession, of very distinct crystals of foliated tellurium, one of which was also figured by Mr. Phillips. Perhaps, among the larger collections of the ores of tellurium, these white crystals may occur in sufficient quantity for chemical examination.

ON THE JUICE OF ESCHSCHOLZIA CALIFORNICA.

Not being aware that any scientific author has made mention of the very peculiar *juice* contained in that beautiful plant the *Californian Eschscholzia*, I beg to call the notice of the medical and chemical readers of the Philosophical Magazine to this point. The juice is of a yellowish colour, and is given out very readily from the stems and other parts of the plant; it smells exactly like *muriatic acid*, and possesses in some degree the property of taking out ink-spots from linen, &c.

This plant is a species of the new genus *Eschscholzia*, belonging to the natural order *Papaveraceæ*; and, like some of the same order, the common Celandine (*Chelidonium majus*) and the Opium Poppy (*Papaver somniferum*), for instance, it has a similar powerful juice, which I think probably may hereafter, like theirs, become of use to the physician, as well as of service to the chemist.

For this reason, may I beg that the Editors will give these lines a place in their Magazine; hoping that as the *Eschscholzia Californica* is now common in many of our gardens, a chemical analysis of its strong juice, and the experiments consequent thereon, may develop the causes of its muriatic-acid-like scent, and perhaps render it beneficial in medicine.

London, Dec. 3, 1834. J. H. N.

ANALYSIS OF NADELERZ. BY HERRMANN FRICK.

The mineral examined was found in the gold veins of Beresow in the Ural, hitherto the only known locality of it. It occurs commonly disseminated in quartz in very slender acicular prismatic crystals, deeply striated, and exhibiting an imperfect cleavage pa-

rallel to the principal axis. Its colour when recently fractured is dark lead grey with metallic lustre, which gradually changes to brown. Specific gravity 6·757.

The results of two different analyses are as follows:

		Corresponding proportion of Sulphur.		Corresponding proportion of Sulphur.
Sulphur ..	16·05		16·61	
Bismuth ..	34·62	7·85	36·45	8·26
Lead	35·69	5·57	36·05	5·60
Copper ..	11·79	2·96	10·59	2·69
	98·15	16·38	99·70	16·55

Poggendorff, band xxxi. § 529.

Hence in the composition of nadelerz there are three atoms of bismuth, two of lead, and one of copper, combined respectively with one of sulphur.

AMMONIA IN THE VEGETABLE ALKALIES.

M. Matteucci remarks that the existence of azote and hydrogen in the form of ammonia in the vegetable alkalies, is one of the points respecting which there is yet uncertainty. According to the analysis of Liebig, the relation between the acid and the azote of the base, is exactly the same as in ammoniacal salts; and the vegetable alkalies, like ammonia, form true salifiable bases only when combined with water; and lastly, the salts which have a vegetable alkali for their base, are similar to ammoniacal salts as to isomorphism with other salts: from these circumstances M. Matteucci concludes that a part at least of the azote of these alkalies is in the state of ammonia. It will be readily admitted that voltaic electricity offers the most proper method of solving the question; for this purpose it is sufficient, though difficult of execution, to apportion the force of the electric current so as to separate the binary compounds without transforming them. For this purpose an apparatus, precisely similar to that used by M. Becquerel, was employed, and some pure narcotine was put upon a slip of turmeric paper moistened with æther: the same was also done with reddened litmus paper. Although the alkaline nature of narcotine is well ascertained, yet it is well known that it does not produce the same effects as other alkalies upon the colours of turmeric and reddened litmus. After some time the blue colour of the litmus reappears, and the turmeric is reddened. Still further to investigate this subject, sulphate of copper, in very fine powder, was mixed with pure morphia and placed on paper moistened with alcohol, which touched the copper of the small pile; in a few minutes the mixture became blue: this experiment succeeded also when a pile of ten pairs was employed. As it is impossible to believe that this ammonia is formed by the combination of the azote and hydrogen developed by the pile, the existence of this body in a state of combination in the organic alkalies must be admitted.—*Ann. de Chim. et de Phys.* tom. lv. p. 317.

ON THE EMPLOYMENT OF INSOLUBLE SALTS IN ANALYSIS. BY M. HORACE DEMARÇAY.

One class of metallic oxides is characterized by its want of power to saturate acids perfectly, and by the property of not dissolving in these agents unless they are in excess. The oxides of iron, chromium, tin, bismuth, and antimony, as well as the oxides of the electro-negative metals, belong to this class. It is possible to precipitate these oxides without the intervention of any powerful affinity. The carbonates of lime, barytes, strontia, or magnesia, when added to a cold solution of peroxide of iron, separate it so completely that the most sensible reagents indicate no trace of it. In this way the peroxide of iron may be separated from the protoxide, and also from the oxides of manganese, cobalt, or nickel, with more facility and accuracy than by any other method. The carbonates of barytes and strontia are to be preferred, on account of the facility with which they are separated from the fluid in which they are dissolved, or from the peroxide of iron with which they are mixed. This process is excellent for procuring oxide of cerium entirely free from peroxide of iron. Oxide of bismuth acts like peroxide of iron; carbonate of barytes separates it cold and perfectly from peroxide of copper; lead, manganese, and nickel may be separated in the same manner. Carbonate of barytes precipitates in the same manner the oxides of antimony and peroxide of tin from solution in muriatic acid, and it may be employed to separate lead from copper, which are united in many alloys. The protoxide of tin is not separated by carbonate of barytes; this process may, therefore, be used to separate tin from antimony. Oxide of chromium acts like peroxide of iron with carbonate of barytes; this metal may, therefore, be separated by it from the oxides of nickel, cobalt, manganese, and those which have been mentioned when treating of peroxide of iron. If the solution contains peroxide of iron, that will be precipitated with the oxide of chromium, and they may be separated by calcination with potash.

In order to separate iron from chromium, when both are dissolved in an acid, it is sufficient to saturate the liquor with sulphuretted hydrogen in order to reduce the iron to the state of protoxide, and then the carbonate of barytes precipitates the oxide of chromium only.

Both oxides of mercury, when dissolved in nitric acid, are precipitated, like the oxide of bismuth, by carbonate of barytes. The carbonates of the alkaline earths have been proposed to separate different oxides; but the proposal has not met with the attention which it deserves, because the most important circumstance has not been sufficiently observed, which is, the temperature at which the precipitation ought to be effected. The action of these salts varies at different temperatures. Thus, the muriates and nitrates of cobalt, nickel, manganese, zinc, and copper are entirely decomposed by the carbonates of lime and magnesia, but only at a certain temperature. Copper and zinc are precipitated first, cobalt and nickel afterwards, manganese the last; but these metals cannot be separated from each other by this method.—*Journal de Pharmacie*, October 1834.

Meteorological Observations made by Mr. THOMPSON at the Garden of the Horticultural Society at Chiswick, near London, and by Mr. VEALL, at Boston.

Days of Month. 1834.	Barometer.			Thermometer.			Wind.		Rain.	
	London.		Boston.	London.		Bost.	Lond.	Bost.	Lond.	Bost.
	Max.	Min.	8½ A.M.	Max.	Min.	8½ A.M.				
● Nov. 1	30·126	30·120	29·47	58	46	52·5	W.	W.	...	...
2	30·142	30·081	29·50	61	45	53	SW.	calm	...	...
3	30·070	30·040	29·54	63	38	47	SW.	calm	...	...
4	30·148	29·926	29·44	60	55	49	SW.	W.	0·02	...
5	29·729	29·558	29·02	61	56	63	SW.	W.	·18	...
6	29·746	29·666	29·03	63	53	58	SW.	W.	·52	...
7	29·507	29·437	28·98	62	46	57	S.	W.	·03	0·50
☽ 8	29·453	29·451	28·83	59	42	48	SW.	W.	·31	...
9	29·556	29·478	29·03	55	46	44	S.	calm	·24	·03
10	30·109	29·854	29·54	57	35	45·5	NE.	NE.	·01	·16
11	30·291	30·191	29·78	50	40	45	NE.	calm	...	...
12	30·333	30·299	29·93	54	37	42	E.	E.	...	...
13	30·370	30·302	29·85	55	33	38	NE.	calm	...	...
14	30·424	30·337	29·95	47	33	39	NE.	calm	...	...
15	30·452	30·420	29·94	48	35	38	NE.	calm	...	...
○ 16	30·399	30·315	29·90	48	36	43	N.	calm	...	...
17	30·213	30·086	29·72	51	40	44	NW.	calm	...	...
18	30·243	30·161	29·60	44	30	44	NE.	calm	...	...
19	30·293	30·201	29·81	43	30	40	E.	calm	...	...
20	30·060	29·840	29·67	40	30	41	NE.	E.	...	...
21	29·792	29·785	29·45	45	34	39·5	E.	calm	·06	...
22	29·880	29·739	29·45	47	42	43	E.	calm	...	...
23	30·151	30·052	29·65	44	33	44	NE.	calm	...	...
☾ 24	30·150	30·051	29·78	48	38	42	E.	calm	...	...
25	29·947	29·878	29·58	40	36	42	E.	calm	...	...
26	29·943	29·882	29·42	40	25	40	NE.	calm	...	...
27	29·993	29·889	29·47	51	35	43	SW.	calm	...	...
28	29·791	29·338	29·22	51	39	47	SW.	calm	·12	...
29	29·316	29·102	28·74	50	42	41·5	SW.	W.	...	·10
● 30	29·736	29·592	29·05	54	31	45	W.	calm	·26	...
	30·452	29·102	29·47	63	25	45·2			1·75	0·79

Remarks.

London.—Nov. 1. Fine. 2. Cloudy. 3. Very fine. 4. Foggy: fine. 5. Stormy and wet. 6. Overcast: heavy rain at night. 7. Cloudy. 8. Clear and fine. 9, 10. Rain. 11. Fine. 12—14. Cloudy and cold. 15—18. Overcast and fine. 19, 20. Frosty: fine. 21. Overcast: hazy at night. 22. Foggy. 23. Cloudy: clear at night. 24. Fine. 25. Cold dry haze. 26. Overcast and cold. 27. Clear and frosty: fine. 28. Fine: rain at night. 29. Fine. 30. Very fine: rain at night.—The wind being from E. or N.E. from the 10th till the 26th, the barometer stood generally high; but suddenly changing to S.W. on the 27th, the barometer fell very low on the following days. The depression, however, was accompanied with less rain than is usually the case. The quantity of rain was only half the average, and fogs were also less prevalent.

Boston.—Nov. 1, 2. Cloudy. 3, 4. Fine. 5. Stormy. 6. Fine. 7. Rain: stormy P.M. 8. Fine. 9. Cloudy: rain early A.M.: rain P.M. 10, 11. Cloudy. 12—14. Fine. 15, 16. Cloudy. 17. Fine. 18. Cloudy. 19, 20. Fine. 21—26. Cloudy. 27. Fine. 28. Cloudy: rain P.M. 29. Cloudy. 30. Fine.

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FEBRUARY 1835.

XI. *On the Practicability of alloying Iron and Copper.* By DAVID MUSHET, *Esq.*

To Richard Phillips, Esq., F.R.S. L. & E. &c.

SIR,

IN perusing the other day Dr. Lardner's third volume on metals*, I met with the following unqualified assertion: "As to alloying copper with iron, the notion not only appears absurd, but unsupported by evidence." As at the present moment Dr. Lardner's publication may be considered a text-book of popular instruction, such a statement might lead to a settled conclusion that to alloy iron and copper is under all circumstances impossible. Now the contrary is the fact; and having considered this operation for many years as one which, if happily effected, would materially contribute to the perfection of many of our mechanical contrivances, I hope I shall be excused for entering on the subject somewhat particularly.

In the first place, I see no *primâ facie* reason why it should be absurd to expect that iron should unite with copper as well as it does with other metals. Then as to the evidence, I think that most chemical works state the fact as a matter of course, never doubting the practicability of the measure; and in your own Magazine, vol. xlix., I find some experiments on the union of iron with copper; which shows that the subject has not been recently altogether overlooked. The uncertainty which prevails upon the subject arises from the want of accu-

* "Manufactures in Metal, vol. iii. Tin, Lead, Copper, Brass, Gold, Silver, and various Alloys," p. 174.

racy in defining the nature and quality of the iron which has been the subject of the union. Most of the books entirely overlook the various states of iron, and fail to distinguish whether the subject-matter of the experiment was cast iron, or steel, or iron in a state of malleability. The same remark applies to the experiments of Mr. P. N. Johnson as above, who, though he states that he effected an union between iron and copper, yet leaves it doubtful whether the iron was not steel or cast iron instead of pure or malleable iron. The well-known affinity of iron for carbon precludes the possibility of malleable iron being heated and melted in contact with a large dose of charcoal (as was the case in his experiments,) without its passing into the state of steel or cast iron. So that the experiments of Mr. Johnson may be considered as representing, not the union of copper with wrought or malleable iron, but with cast steel or crude iron. Whether or not these were examples of a real chemical alloy, or of a mere mechanical mixture, may be gathered from the following remarks, which are grounded on an extensive series of experiments.

It had for many years appeared a desideratum to me to form castings for shafts, cranks, levers, beams, &c., of a substance that should possess the stiffness of cast together with the power of tension and strength of wrought iron. It occurred to me that such a discovery would enable the engineer to construct more complete and convenient forms (particularly in the machinery belonging to steam-boats and locomotive engines,) than he is at present able to obtain from the cumbrous forging, turning, and fitting of malleable iron. Such an union of strength I naturally sought for in a mixture of iron and copper; and knowing that the copper ores of this country are principally sulphurets of iron and copper, I commenced my experiments by attempting the joint reduction of the iron and copper. After many failures I so far succeeded as to effect a perfect reduction into malleable matter of the whole contents of any given sulphuret. But upon examining the results, it was found that a very great uncertainty prevailed as to their strength and quality; and I soon ascertained that I had only succeeded in obtaining a perfect separation from the ore, of the united products of iron and copper. These masses of alloy were arranged and classified as follows:

1st. Ingots of a coppery coloured surface, covered with an exterior blackish shale in cooling resembling iron; breaking with a pale uniform homogeneous fracture, and producing an action more or less on the magnetic needle.

2ndly. Ingots with a gray coppery surface, covered also with an exterior blackish shale in cooling resembling iron, the under surface of a deep red coppery colour. Fracture

specular, and beginning to exhibit distinct grains of copper' apart from the iron, as if this metal had been saturated with copper. Small hard and bright iron points appeared under the file. These ingots were obedient to the magnet.

3rdly. Ingots with an iron-coloured surface, and coppery tints displayed under a black thin shale. Hard, and filing to a coppery colour, mixed with bright spots. Fracture specular, exhibiting a mixture of iron and copper, in which the former appeared to prevail. Powerfully acted on by the magnet. The lower surface cellular and crystallized, resembling products of fused steel.

Though I have divided these products into three classes only, yet I obtained many intermediate results, the iron present in which I estimated at from 5 to 70 per cent. of the weight of the copper. Beyond 5 or 7 per cent. of iron, no chemical union took place; and as the quantity of iron revived, was in proportion to the charcoal added, so in the same proportion did the separation of the two metals from each other take place. From this it was inferred that malleable iron (*i.e.* iron containing the least possible quantity of charcoal,) would unite and form a proper alloy with copper, but that steel or cast iron would not do so. To try the validity of this reasoning, a new series of experiments was instituted, having for their object the direct union of a portion of copper with iron in the various states of cast iron, steel, and malleable iron, the general results of which I will state as briefly as possible, without going into a detail of the various experiments.

Pure malleable iron may be united with copper in any proportion, until it equals, or even exceeds, the weight of the copper; the intensity of the copper colour increases, till the quantities are equal; and the fracture then becomes paler, in proportion as the quantity of iron exceeds that of the copper. With 50 per cent. of iron the alloy possesses great strength: its hardness increases with the quantity of iron, but its strength afterwards decreases, and in cutting, it opens before the chisel. The loss of strength in proportion as iron is added, arises, I imagine, from the fibre of the copper being injured by the very high temperature required to fuse the increased quantity of malleable iron. The fracture of the ingots thus obtained is always specular, with a glance arrangement, which betokens a tendency to brittleness.

If steel is fused with copper in the proportion of $\frac{1}{20}$th of the latter to $\frac{19}{20}$ths of the former, an ingot resembling, and crystallized like cast steel, will be obtained, but useless for forge purposes, and incapable of receiving an edge. Not the slightest symptom of copper, either on the surface or in the fracture,

can be perceived, but a very considerable increase of hardness may be observed.

When copper is fused with $\frac{1}{10}$th of its weight of bar steel, an ingot is obtained which outwardly resembles the former, with the radiated linear crystallization less distinct. But the fracture, which is hard and brittle, shows, by minute points of copper, the commencement of an indisposition or inability to further union, or alloy, between the two metals.

Again, when $\frac{1}{5}$th the weight of copper is added of steel, an ingot is obtained which exhibits, when filed, a partially coppery appearance, of a deep red on the lower, and steel bright on the upper surface. The fracture displays a regular grain, which indicates an intimate mixture of copper and iron, apparently of greater strength than in the two former alloys.

When $\frac{1}{3}$rd of copper is added to the steel, the former seems to separate, and seeks in considerable quantities, in a soft and malleable state, the lowest part of the crucible. The fracture exhibits the copper in streaks and knots, indicating a decided want of union*.

White cast iron, which resembles steel in the quantity of carbon which it contains, affords nearly the same result when fused with similar portions of copper; the alloy, however, possesses less strength, and a greater tendency to disunion when the proportion of copper is increased beyond $\frac{1}{20}$th.

The union of copper with gray cast iron, if at all practicable, must take place in very minute quantities; for in fusing 5 per cent. of copper along with No. 1, or smooth-faced pig iron, specks of deep red coloured copper were found upon the lower surface of the ingot, and similar traces were discernible in the fracture. With $\frac{1}{10}$th the copper became of a deep red colour, separated in leaves, and attached itself to the outside of the cast iron; and when copper to the extent of $\frac{1}{5}$th was tried, a solid button of copper was found beneath the cast iron in the bottom of the crucible.

From all I have learnt on this subject, I conclude that copper unites with iron in proportion as the latter is free from carbon; hence it would appear impossible to produce a mixed metal, or alloy of copper and iron, by smelting in a blast furnace, in contact with carbonaceous matter, an ore containing both these metals. It is true that we have ores which, when

* Steel, both English and Indian (or wootz), was alloyed with copper, in the proportion of two per cent. of the latter, by Messrs. Stodart and Faraday, in their experiments on the Alloys of Steel; but of the value of this alloy, they observe, "we have doubts." They did not attempt to produce it in the large way. See Quart. Journ. of Science, vol. ix. p. 325, 329; and Phil. Mag. vol. lvi. pp. 31, 54; vol. lx. p. 371.—Edit.

properly smelted, would afford at the first fusion crude steel, which contains a minimum dose of carbon, and to which might be added as much copper as would chemically unite with it, probably from 5 to 7 per cent. But this quantity, I am afraid, would be too small to form an alloy possessed of the strength and power of resistance necessary to made castings for the purposes already mentioned.

Though I have clearly established by numerous experiments the practicability of a perfect union of malleable iron with copper, in every reasonable proportion, yet as this alloy can only be made in a close crucible, it is obviously impossible to employ it for castings of a considerable weight or size. I do not, however, despair of overcoming this difficulty, and of gaining the object I have long had in view by a different system of alloy, in which copper must necessarily form an essent ialingredient.—I am, Sir, your very obedient servant,

Coleford, Gloucestershire, Dec. 13, 1834. DAVID MUSHET.

XII. *Further Notice of the Vibration of Heated Metals; with the Description of a new and convenient Apparatus for experimenting with.* *By* ARTHUR TREVELYAN, *Esq.**

SINCE my communication on the above subject, published in your Journal of November 1833, I have made numerous experiments; but the only result I have obtained worthy of notice, is that of vibration accompanied with sound when a heated bar of copper or brass, at a temperature of 208° and 212° Fahrenheit, was placed on a ring of bismuth, having failed in producing it in my previous experiments. With a brass or copper bar placed on a fusible alloy, composed of 5 parts of lead + 3 tin + 8 bismuth, vibration commenced at a temperature of 203° Fahrenheit. On a ring of fusible alloy containing the same ingredients and in the same quantities as the former, with the addition of one and a half part of mercury, no effect was observable.

The accompanying are figures of a convenient apparatus for experimenting with different metals on a small scale.

Fig. 1. A gun-metal bar having a groove C, with under-cut edges to receive the wedge of any metal A, held fast with a pinching-screw B.

Fig. 2. A gun-metal ring with wedge of any metal inserted in a groove at D.

Fig. 3. Stand, with two uprights and pinching-screw. The

* Communicated by the Author, whose former paper will be found in Lond. and Edinb. Phil. Mag., vol. iii. p. 321. Prof. Forbes's paper on the same subject will be found in vol. iv. p. 15.

ring being placed, the pressure of the screw E, forces it against the two uprights, which tightens it, and by that means fixes the wedge D in figure 2.

Fig. 4. Ring and stand complete for experimenting with.

Fig. 1.

Fig. 2.

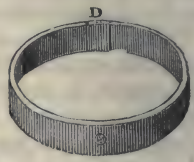


Fig. 3.

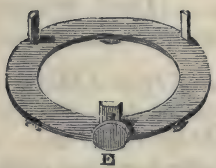
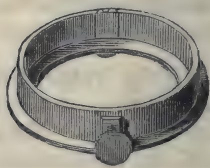


Fig. 4.



XIII. *On the Signs of the Trigonometrical Lines.* *By* W. G. Horner, *Esq.**

1. REGARDED as a demonstration of the algebraic affections of the trigonometrical lines, the following statement (it is hoped) will be found to combine graphical distinctness with mathematical evidence. But its chief presumed recommendation is its *completeness.* In every treatise that has fallen in my way, the affections of the *chords* have either been overlooked, or imperfectly, not to say erroneously, discussed. To remedy this fault, the entire system of chords is introduced into the annexed diagrams, and the chord is made a principal element in the investigation.

2. The lines C A, A T, (fig. 1.) being at right angles to each other, about the points C and A let two indefinite right lines C P, A P, revolve continuously in the direction $\curvearrowright$. At the outset let the former coincide with C A, and the latter with A T; and let the latter revolve with half the angular velocity of the former. Then [α] when C P next coincides with C A, A P will coincide with T A produced in the direction averse from T; for this is only saying that the former will

* Communicated by the Author.

Fig. 1.

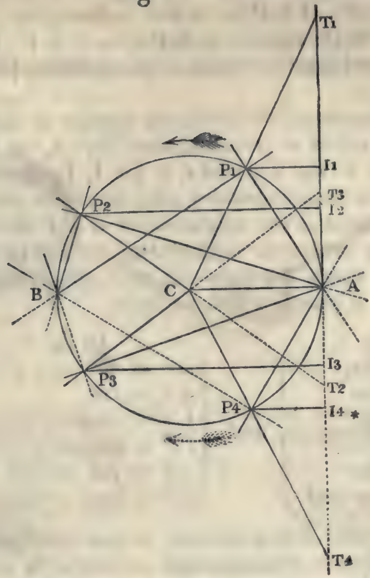
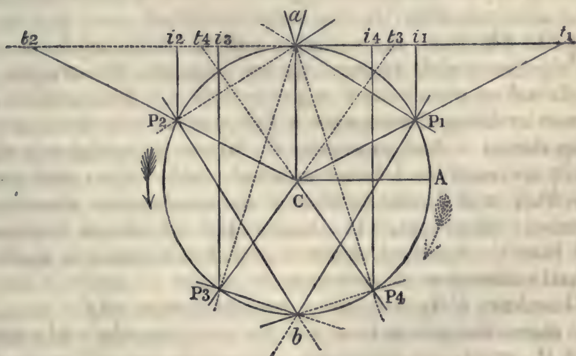


Fig. 2.



traverse four right angles while the latter traverses two. Also [β] the point P of the intersection of the revolving lines will describe a circle. For, drop P I perpendicular to A T or its continuation. In either case the $\angle$ A C P = 2 I A P; for it is manifestly indifferent whether these angles are estimated *from* the simultaneous outset, or *to* the simultaneous arrival (α).

Now (Euc., i. 32.), $90° + IAP = ACP + APC = 2IAP + APC \therefore 90° - IAP = APC$. But (Euc., i. 29), $90° - IAP = CAP$; wherefore $APC = CAP$. Consequently $CP = CA$ constantly; which is the defining property of the circle. Q. E. D.

3. This demonstration obviously applies to angles in every quadrant. And if a is substituted for A, at a quadrant's distance from it (fig. 2.), and i, t, for I, T, the same applies *verbatim* to the complementary arcs or angles also. Now, T, or t, being placed at the concurrence of C P and A T, or $a\,t$ and B P being moreover supposed to revolve in the same direction $\curvearrowright$ about the point B, or b, diametrically opposite to A, or a, it is manifest that we have

$$\begin{array}{ccc} \text{In fig. 1.} & & \text{In fig. 2.} \\ \left.\begin{array}{l} AI = \text{sin} \\ AT = \text{tan} \\ CT = \text{sec} \\ IP = \text{versin} \\ AP = \text{chd} \\ BP = \text{sec-chd} \end{array}\right\} & \text{and} & \left\{\begin{array}{l} ai = \text{cos} \\ at = \text{cot} \\ Ct = \text{cosec} \\ iP = \text{covers} \\ aP = \text{1st co-chd} \\ bP = \text{2nd co-chd} \end{array}\right\} \text{of } ACP. \end{array}$$

4. Now, in the first quadrant, to the conditions of which all other quadrants are supposed to conform, the lines A T, A P, C P, B P, are terminated at A, C, B, and extensible only in the directions T and P. If that which is affirmed respecting any of these lines requires, in any specified quadrant, to be accommodated to the continuation of such line in the opposite direction, the variation will be indicated by a negative sign, as is well known. In my diagrams, the original and accidental or positive and negative lines are distinguished, the former by being drawn with a full stroke, and the latter by being dotted. And to render the whole as completely elucidatory as possible, I have annexed, rather than suffixed, to each P, I, and T, the number of the quadrant to which it appertains, following in this respect the convenient notation of Mr. Hind. A dotted arrow is also introduced, to show the negative character of such arcs or angles as imply a revolution contrary to the direction originally assumed.

If these minutiæ answer the purpose intended, of making these diagrams an intelligible substitute for dry tables of + and —, I am sure those who have no need of either will have the good nature to excuse them, for the sake of those who will find them useful.

5. From the diagrams, then, it is apparent that the variations of affection of all the lines, *except the chords*, are completed within the course of four quadrants, and that they ac-

cord with the statements given in every treatise. But it is also apparent from [α], that the line A P *and its continuation backwards* from A, complete not their revolution in less than *eight* quadrants. The affections, in short, of the system of chords are seen to be as under:

In quadrant ...	1	2	3	4	5	6	7	8	
chord.........	+	+	+	+	−	−	−	−	
sec-chd	+	+	−	−	−	−	+	+	&c.
1st co-chd ...	+	−	−	−	−	+	+	+	
2nd —— ...	+	+	+	−	−	−	−	+	

6. The same results may be obtained from the analytical statements, chd A $= 2 \sin \frac{1}{2}$ A, sec-chd A $= 2 \cos \frac{1}{2}$ A, co-chd A $= 2 \sin \frac{1}{2} \left(\frac{\pi}{2} \mp \mathrm{A}\right)$, on exchanging A for $\pi \mp \mathrm{A}$, $2\pi \mp \mathrm{A}$, $3\pi \mp \mathrm{A}$, $4\pi \mp \mathrm{A}$. It would therefore be better, perhaps, to adhere to this mode of stating the value of the chord, as Woodhouse does in the passing notice he gives it, than by resting on the irrational form to leave the sign uncertain. The plan of Mr. Hind's first chapter, it is true, restricted *him* in this respect; but his unguarded assertion, that "the chord is positive in every quadrant," has a direct tendency to mislead, and should be revised. The versed sine alone is always positive.

In conclusion, it may be remarked, that whereas for every other line or function (f) the formula of reduction to the tables or diagrams is $f(2n\pi \pm \mathrm{A}) = f(\pm \mathrm{A})$, for the chords it is, chd $(2n\pi \mp \mathrm{A}) = (-1)^{n-1}$ chd $(\pm \mathrm{A}) = \mp\ (-1)^n$ chd A.

Mnemonic Hint.

Setting aside the versed sine and chord, whose affection, as well as value, is clearly expressed by $1 - \cos \mathrm{A}$ and $2 \sin \frac{1}{2} \mathrm{A}$, the affection of the principal lines is indicated by the *order* in which it is most natural and usual to name them, viz. SINE, TANGENT, SECANT. For, in the 1st quadrant all being +; in the *2nd* all are −, *except* the SINE and its reciprocal the cosecant. In the *3rd* all are −, *except* the TANGENT and its reciprocal the cotangent. In the 4th all are −, except the SECANT and its reciprocal the cosine.

Note (relative to a formula in Lond. and Edinb. Phil. Mag., vol. v. p. 191.)—Having still a space left, I take the opportunity of remarking, that the method of elimination by the common measure, although tempting by its facility and elementary nature, is too defective to deserve recommendation.

By adhering to the method by combinations or symmetrical functions, the complete formula

$$(x^2 - s\,x + p)\,\{(3\,a - s)\,x^2 - 2\,(a\,s - p)\,x + a\,p\} = 0,$$

would have resulted in place of (C), which contains only the latter factor; and the evidence adduced would have been somewhat more clear.

XIV. *Of the Structure of Animals. By the Rev.* Patrick Keith, *F.L.S.*, &c.

[Concluded from p. 16.]

Class 2. If we look at an individual of the class of Birds, we shall find that it exhibits the same general type of structure with that of the Mammalia, consisting of head, neck, body, limbs. The head, as in the foregoing class, is the seat of the organs of sense, furnished with and terminating in a bill, by which the individual picks up and breaks its food. The form of the bill differs much in different species, and serves as a mark to discriminate tribes or families. The head, neck, and body are covered with feathers, which are often adorned with the brightest and most brilliant colours. The neck assumes the circular form, and often displays peculiar beauty, as well as peculiar flexibility, as any one who has seen a swan in the act of swimming will, with Milton, readily admit:

> " .... The swan, with *arched* neck
> Between her white wings mantling, proudly rows
> Her state with oary feet."—*Paradise Lost*, b. vii.

The greatest bulk of the body is around the breast, tapering towards the tail, which is composed of feathers of a peculiar form,—magnificently illustrated in the tail of the peacock. The fore limbs assume the position and fan-like form of wings, to fit the individual for its flight in air; and are often composed of, or rather covered with, a plumage that is most splendidly brilliant. The hinder limbs always terminate in feet, divided into toes tipped with claws, some genera having the toes separate, as the pheasant and partridge; and some having them united with a membrane, as the swan and goose. The former are land birds; the latter are water, or web-footed birds.

Class 3. In this class, the class of Fishes, the vestiges of the general type, though much metamorphosed, can still be readily traced. The head is very distinctly visible, furnished with its projecting mouth and devouring jaws. The eyes are sufficiently conspicuous; but the other organs of sense have no very visible development of external parts. The head is

joined to the body without the intervention of any distinct portion that can properly be called a neck; but about the junction of the head and body we find on each side an external organ peculiar to fishes, namely, the gills,—their organ of respiration. The body, which is covered with scales, is rounded, and tapering from head to tail, as in the eel; or a little flattened in a vertical direction, as in the trout and salmon; or much flattened in a horizontal direction, as in the sole and flounder, and in all flat fish: the limbs, whether anterior or posterior, are metamorphosed into fins to fit them for the act of swimming in water. By the lateral flexion and extension of the caudal fins the body is impelled forwards with great force, ascending or descending chiefly by means of the compression or dilatation of the swim-bladder, an organ with which most fishes are furnished; but such as are destitute of it, like soles and flounders, must be content to swim very near the bottom. Some fishes have the capacity of leaping out of the water; and one, *Trigla volitans*,—the flying fish,—has the very singular property of being able to take a short flight even in air.

Class 4. In this class, the class of Reptiles, the general type is in most cases very obvious, exhibiting a head, with a mouth and eyes distinct; a visible neck; a body naked, as in the frog; or covered with shell, as in the tortoise; without a tail, as in the toad; or furnished with a tail, as in the lizard. The limbs, anterior and posterior, are so excessively short as scarcely to be able to raise the body above the level of the ground; and in the order *Serpentes* even limbs are wanting. Many of the *Reptilia* are amphibious, and can live either on land or in water; and most of them during the winter months sink into a state of torpidity, from which they are aroused only by the returning warmth of the succeeding spring.

Division II. The Mollusca.—The next division of animals in the descending scale is that of the *Mollusca*. They are distributed into three classes,—the *Cephalopoda*, in which the feet, or organs of locomotion, are inserted in the head; the *Gasteropoda*, in which the foot, or organ of locomotion, is the abdomen; and the *Acephala*, in which no distinct head is visible. In each class there is an order that is inclosed in a shell, or testaceous covering; and an order that is naked.

Class 1. In the first class we find the *Sepiæ*, or cuttle-fish. They are of the order of naked Mollusca, and in their general aspect are but a shapeless mass. The head, however, is distinctly visible, furnished with eyes and organs of hearing, as well as with presumed organs of smell, from the fact of their

aversion to strong-scented plants *. Around the head there are fixed a number of arms, which are the organs of locomotion and of prehension. In *Sepia officinalis* they are ten in number, two of them being longer than the rest. The arms are furnished with suckers, in the shape of excavated tubercles, by which the individual can fasten itself firmly to external substances, and thus stand, as it were, upon its head. The *Sepiæ* have the peculiar property of ejecting at pleasure from the abdomen an inky-coloured fluid, that darkens the water in their vicinity, and renders them for a time invisible to their pursuers. They are not uncommon on the coast of England.

Class 2. In the second class we have the slug, that infests our gardens and corn-fields during the spring and summer, devouring the radicle, or the cotyledon, or the tender blade of the young plant, and blasting the golden hopes of the too sanguine cultivator. The largest of the tribe, when extended, may be about the size of a finger. The head is furnished with a mouth, by which the individual gathers its food; and with a pair of horns, or feelers, terminating each in a black point, which is regarded as an organ of vision. It slides along upon its abdominal surface by a sort of vermicular movement, leaving a slime behind it; and it has the capacity of contracting its extended body into a very small compass, if affected by fear or hastily interrupted in its peregrinations.

Class 3. In the third class we have the oyster in its shell, the delight of the *gourmand*, or connoisseur in sauces, and so well known to every lover of good things as scarcely to stand in need of any description. It belongs to the order of acephalous bivalves, having its abode in the ocean, but choosing as its favourite habitat the mouths of rivers or of estuaries. It sheds its spawn in the month of May on rocks and stones or other substances at the bottom of the water, to which the young brood clings till detached by the industry of the dredger, to be transported to beds calculated to forward their growth and give additional delicacy to their flavour. The oyster seems to be destitute of all organs of locomotion, and yet it is capable of changing its place. By opening its shell to a certain width it takes in a portion of water, which it has the power of squirting out again with considerable force, and in any direction, and of thus propelling itself to any point in a direction contrary to that of the force exerted.

Division III. THE ARTICULATA.—The third division of animals in the descending scale is the *Articulata*, which have

* Carus, Compar. Anat., i. 74, by Gore.

the body externally divided into a succession of rings, or articulations. They are distributed into the three following classes: The *Vermes*, or worms, in which the body is without any external organs of locomotion; the *Crustacea*, in which the body is covered with a shell; and the *Insecta*, or insects, in which the body is divided by deep indentations into four principal parts,—the head, the corselet, the chest, the abdomen.

Class 1. The first class is exemplified in *Lumbricus terrestris*,—the earth-worm. At its mature size it may be about a span in length, with the circumference of a goose-quill. The head is indistinct, but the mouth is not so. The body is soft and gelatinous, and articulated on the external surface, with a sense of touch chiefly about the two extremities; but without any external and distinct organ, whether of hearing or of sight, and without feet, but covered with projecting bristles, or tufts of hair, which in some measure supply their place.

Class 2. The second class is exemplified in the crab and lobster, shell-fish that are well known. They inhabit rocky shores, or shallows of the ocean, and feed upon sea-weed and all manner of garbage. The head is furnished with feelers and with moveable eyes. The legs are eight or ten in number, with five articulations, the first pair ending in claws or nippers, and, like the body, covered with shell. If they lose a limb by accident, they have the power of reproducing it. Lobsters have a long and articulate tail, covered with a horny coat, composed of several portions that move one upon another. They shed their shells annually, and screen themselves for a few days under the shelter of stones and rocks till the new shell is sufficiently indurated to defend them from the ordinary accidents to which the element they inhabit exposes them. At last they are caught by the art of the fisherman, and forwarded to the tables of the lovers of luxuries, where they are much esteemed for the delicate morsel, or for the rich and piquant sauce which their edible portion affords. The natural colour of the lobster is black; but when boiled it changes to red,—a circumstance that the author of Hudibras has turned to good account in the getting up of one of his ludicrous similes:

> "The sun had long since, in the lap
> Of Thetis, taken out his nap;
> And, *like a lobster boiled*, the morn
> From black to red began to turn."
>
> *Hudibras*, part ii. cant. 2.

Class 3. The third class is exemplified in the silk-worm, *Phalæna Mori*. If in its native country of China or of India, it lays its eggs in summer on the boughs of the mulberry-tree.

They are small yellow globules, about the size of a millet-seed, and a single female will lay several hundreds of them; but where such trees are not to be found, as in the case of the transporting of the species into other climates, the female will lay her eggs on whatever substance she may happen to have access to. To this substance they remain agglutinated during the winter that succeeds, and begin to be quickened by the return of spring, till in the month of May they are evolved into life; that is, as kept in the cabinets of the curious of this country. The protruded insect is now a caterpillar of a very diminutive size, consisting of a head, a mouth, and a body composed of seven rings, and furnished with the same number of feet on each side. If well fed with mulberry leaves it will grow very rapidly, and in the course of five or six weeks will have attained to its full size; that is, to a length of nearly two inches, with a diameter equal to that of a goose-quill. It now sickens and refuses food, and sheds its skin; revives, and feeds, and sickens, and sheds its skin again, and again; and on its third or fourth revival selects, after a day or two of indecision, a suitable spot for future operation, and begins to weave its cocoon, which it completes in about a week. Imprisoned in its cocoon, it puts off the caterpillar form entirely, and is metamorphosed into a *chrysalis* or *pupa*, in which state and prison, after a sojourn of about another week, it eats or forces its passage out, and is ultimately transformed into an *imago*, or moth, not adorned with brilliant colours, but exhibiting in its form and structure much of beauty and of elegance, and of an indescribable something that seems to indicate its Oriental origin. In this state it lives three or four days, occupied in the process of propagating the species, and of laying its eggs; and this done, it dies.

Division IV. The Radiata.—The fourth and last division in the descending animal scale is that of the *Radiata*, including the zoophytes of the earlier botanists,—whose leading character is that they have their parts arranged in a radiant or divergent direction around a common centre. The division forms a class, consisting of the five following orders:—1st, *Echinodermata:* the body inclosed in a crustaceous covering, beset with spines. 2ndly, *Medusæ*, or sea-nettles: the body soft and gelatinous, stinging the hand that touches them, and furnished with tentacula. 3rdly, *Corals* and *corallines:* the body covered with a shell-like or stony crust, or surrounding an insensible stalk,—*stirps radicata*, attached,—the mouth furnished with tentacula. 4thly, *Polypi:* the body a bag of jelly, pedicled or without a pedicle, but unattached,—*stirps libera, corpus liberum*,—the mouth furnished with tentacula. 5thly, *Infusoria:* the body a gela-

tinous globule, with no external organ or apparent orifice.* Professor Grant† has shown that the orders arising out of this division may be increased with advantage to the science; but those we have adopted are sufficient for general purposes.

1st. The first order is exemplified in the genus *Asterias*, or sea-star, with its five radiating lobes; or in the genus *Echinus*, or sea-urchin, with its thousand spines. These genera are common on the shores of England; and when the inclosed animal dies, the empty covering is often to be met with lying on the sea-beach, as it may have been accidentally thrown up and left by the flux and reflux of the tide.

2dly. The second order is exemplified in the genus *Actinia*, —animal flower, or sea anemone. It is found in great abundance on the coasts of the West India islands. It is club-shaped, fig-shaped, or cylindrical, and fixed by the smaller or lower end to rocks, or to stones lying in the sand. To this mode of attachment the *Actinia sociata* is an exception, the foot being fixed, not immediately to the rock, but to a firm and fleshy tube, that creeps along horizontally, and sticks fast to the surface, resembling in some degree the *souche souterrain* of the common brakes. At the upper extremity there is a single opening, which is the mouth, leading directly to the stomach, which is a blind sac. The tentacula, when expanded, are said to exhibit an appearance similar to that of the petals of the anemone, whence the name. They are tinged with a variety of bright and brilliant colours, and are the instruments which the animal employs in the seizing of its prey. The *Actiniæ* are very voracious. They will swallow a muscle or an oyster entire; and after having extracted the internal nutriment by the digestive power of the stomach, they will again eject the shell by the same aperture at which it entered. They are also remarkable for their capability of being multiplied by division to any extent. Cut up a single individual into a thousand pieces, and each piece will become a complete *Actinia*, furnished with all the peculiarities of its species ‡.

But an example more within the reach of the zoological student is that of the *Medusæ*, common on the shores of the British isles; but better known, perhaps, by the vulgar appellation of sea-blubber. They are of a globular form, of a soft and pulpy consistence, and of a shining pale blue colour, dashed with a tinge of violet. You may see them approaching

* [This statement agrees with the views respecting the *Infusoria* which, until lately, were entertained by naturalists; but the recent discoveries of Ehrenberg (and it might be added the neglected observations of Gleichen,) have shown that they possess a mouth, many stomachs, and other elements of a complex organization.—Edit.]

† Lectures at the London University, Nov. 1833.

‡ *Encyclopædia Britannica*, "Animal Flower."

the coast with a flood tide, floating or drifting on the surface of the wave, sometimes singly, and sometimes in multitudes, under the semblance of a large lump of jelly,—in *Medusa aurita* not less than three or four inches in diameter,—with their tentacula spreading around them. They emit a phosphorescent light in the night, and when voyaging in large shoals illuminate the surface of the deep. They sting the hand that touches them, and cause a tingling pain.

3rdly. The third order includes corals, corallines, and sponges, in which a sensitive body surrounds an insensible stalk, or is inclosed in an insensible covering,—stony, crustaceous, or horny; not constructed by the animal itself, but congenital with it; not phosphatic, but calcareous,—*stirps radicata*,—attached. The former varieties occur in the *Gorgoniæ*, the latter in the *Tubiporæ* and *Celleporæ*.

4thly. The fourth order is that of the *Polypi*, the body being a mere bag of jelly attached to a *stirps libera*, as in the case of the sea-feather; or wholly unattached,—*corpus liberum*,—with arms radiating from the mouth. Some of them you may turn inside out, like the finger of a glove, and the animal shall still live. You may cut them into as many pieces as you please, and each piece will become an entire animal. *Hydra viridis* is a good example.

5thly. Finally, the fifth order is that of the *Infusoria*, which consist merely of a small and pulpy globule, capable of a brisk and spontaneous motion, but furnished with no external organ whatever. If a drop of water taken from a ditch or pond in which vegetable substances are becoming putrid, or if a drop of rain water that has stood exposed to the weather for a few days, is put upon the stage of a good microscope, and the eye applied to it, you may see hundreds of them frolicking in that single drop, like fishes in the ocean.

Thus life assumes a great variety of different aspects, according to the tribe or family in which we contemplate its phænomena; and thus a scale of degrees, from man downwards, is evident even from the contemplation of the external structure. In man you have the several parts of the body the most distinctly marked,—the head, the neck, the trunk, the limbs; and the organs of sense the most fully developed,—the eye, the ear, the nose, the palate, the touch; with the peculiar conformation of the foot and of the hand,—the former serving as a basis to support the body in the erect posture, and the latter as an instrument adapted to the thousand different purposes for which man may have occasion to employ it,—whether in the fine arts, as in music, drawing, painting, sculpture; or in the domestic arts, as in the fabrication of clothing or the construction of machinery; or as in the operations of agriculture; or

of war, whether military or naval; or as in the manipulations of chemistry or of anatomy; or, finally, as in almost every art or exercise that man has occasion to perform. Apes, though furnished with four hands, have no hand equal to that of man. If they had the hand, they have not the skill to direct it; and if they had the skill to direct it, they have not the hand. With quadrupeds the case is still worse. From the size and structure of their fabric, many of them have greater strength or greater swiftness than man; but they have no hand. A hoof is but a very inadequate substitute for it; and even with all the advantages of mind, man would be nothing without the master instrument of the hand. Birds, fishes, and reptiles are, by their organization, removed still further from man than even quadrupeds; while the other divisions of the animal kingdom, —the *Mollusca*, the *Articulata*, and the *Radiata*,—are removed even further still. For to whichsoever of them we direct our regard, we find in their external structure nothing that approaches to the type of man, nothing that is fit to be compared to the fabric of the human body, and nothing that equals the capabilities of its several organs, whether for the purposes of sense, of prehension, or of progression; but rather an increasing dissimilitude of structure, in proportion as you approximate the bottom of the scale, till at last you reach the minute and microscopic, but brisk and agile animalcule, that wheels and frolics in its drop of fluid, and yet exhibits no visible indication of being furnished with any external organ or instrument of locomotion whatsoever. Thus man stands, without a rival, at the head of the animal creation,—the image of his Maker, "the noblest work of God"! P. Keith.

Charing, Kent, Oct. 1, 1834.

XV. *On the Reaction which takes place when Ferrocyanuret of Potassium is distilled with dilute Sulphuric Acid; with some Facts relative to Hydrocyanic Acid and its preparation of uniform strength. By* Thomas Everitt, *Esq., Professor of Chemistry to the Medico-Botanical Society, &c.**

(1.) As the decomposition of the ferrocyanuret of potassium by means of sulphuric acid is likely to become the only method by which hydrocyanic acid will be prepared for chemical and medical purposes, on account of the cheap rate at which this salt is now to be had chemically pure; and as in all operations of this sort the more exactly we adhere to the proportions indicated by an accurate knowledge of the na-

* Communicated by the Author.

ture of the interchange which takes place during the process, the more uniform and satisfactory are the results, and the more do we economise our time, I have been induced to examine very narrowly the above reaction.

(2.) Assuming the composition of the crystallized yellow ferrocyanuret of potassium to be 2 K Cy + Fe Cy + 3 Aq, I find that on boiling it with sulphuric acid in a close vessel, $\frac{3}{4}$ths of the potassium remain in solution as bisulphate of potassa, its cyanogen going off as hydrocyanic acid: the remaining $\frac{1}{4}$th combines as cyanuret of potassium with all the cyanuret of iron to form a yellow insoluble salt: thus,

2 proportions of the crystals.	with		
4 K 4 Cy		yield as results	3 Cy H, which escape as gas.
2 Fe 2 Cy	6 $\dddot{S}$		3 ($\dot{K}$ + 2 $\dddot{S}$) bisulphate of potassa in solution.
6 Aq			3 Aq—free.
			K Cy+2 Fe Cy, which fall as yellow salt.

Or in numbers:

2 proportions of salt.	Real sulphuric acid.	Results.
39·15 × 4 potassium		3 (26·39 + 1) hydrocyanic acid.
28 × 2 iron	40 × 6	3 (39·15 + 8) + 6 (40) bisulph. of pot^{sa}.
26·39 × 6 cyanogen		9 × 3 free water.
9 × 6 water		(39·15 + 26·39) + 2 (28 + 26·39) yellow salt.

Hence

2 proportions of salt 212·47 × 2	= 424·94	
6 proportions of sulphuric acid 40· × 6	= 240·00	
		664·94

yield

3 proportions of hydrocyanic acid 27·39 × 3	= 82·17	
3 proportions of bisulph. of potassa 127·15 × 3	= 381·45	
3 proportions of water 9·00 × 3	= 27·00	
1 proportion of yellow salt K Cy 65·54 + 2 Fe Cy 108·78	= 174·32	
		664·94

(3.) This was proved as follows:

(*a.*) 212·5 grains of the crystals of ferrocyanuret of potassium were dissolved in 2 fluid oz. of water, to which were added 600 grains of dilute sulphuric acid of specific gravity 1·179, containing 20 per cent. of real acid, and therefore amounting in all to 120 grains real acid; the mixture was kept boiling in a vessel partially closed to prevent the free ingress of air, till the odour of hydrocyanic acid ceased to be given off:

the yellow salt collected, washed, and dried at 220°, weighed in Experiment No. 1, 88·1 grs.; No. 2, 88·0 grs.; No. 3, 87·1 grs. The calculated number is 87·16. The salt is very liable to assume a delicate green tint unless the air be very carefully excluded from the vessel, and hence its true colour cannot be seen, unless the flask, previously to adding the acid, be filled with carbonic acid gas: the green tint always goes off on drying it at about 300° F.

(*b.*) The colourless solution which passed the filter, leaving the yellow salt on it, and which contained the bisulphate of potassa, required, to render it neutral, of crystallized bicarbonate of potassa, (I used this as being the most definite and manageable salt we have,) in

Experiment No. 1, 152·1; No. 2, 151·0; No. 3, 150·6 grs.

The calculated quantity is $1\frac{1}{2}$ ($\dot{K} + 2\,\ddot{C} + 1$ Aq) 150·58 grs., showing that 3 proportions of sulphuric acid had taken up only $1\frac{1}{2}$ potassa. After neutralizing the liquid with bicarbonate of potassa, it was in two cases evaporated to dryness, and the neutral sulphate weighed, which confirmed in both cases the above results, and proved that no other salt was in the solution: also in one case, the sulphuric acid was precipitated by nitrate of barytes, which proved that all the sulphuric acid was in the solution.

(*c.*) The hydrocyanic acid given off was estimated by taking 106·3 grs. of the ferrocyanuret of potassium in 2 fluid ounces of water, + (300 grains of dilute sulphuric acid of specific gravity 1·179) = 60 grains of real acid, and by means of a tube and cork conducting the vapour into a large receiver, containing a dilute solution of nitrate of silver: the cyanide collected and weighed, gave in

Exp. No. 1, 103 grs.; No. 2, 102·3 grs.; No. 3, 101·4 gr.

The calculated number is 100·8 grains. Most likely in experiment No. 1. the matter was not perfectly dried; but the three come sufficiently near to leave no doubt of the theoretical quantity.

(4.) Hence I conceive that the exposition of the reaction given at the commencement of this paper is fully proved. I am well aware that in the 46th volume of the *Annales de Chimie et de Physique*, p. 77, M. Gay Lussac states that a white salt is produced during this reaction. I have operated with distilled sulphuric acid, conducted the process in a narrow-necked flask, into which a stream of carbonic acid passed during the whole of the boiling, and it was always of a light lemon colour: in ordinary cases, when this extreme care was

not taken, it was greenish. Perhaps M. Gay Lussac poured strong sulphuric acid on the powdered crystals, when a very complicated change takes place. (See Thomson, 7th edition, vol. ii. p. 251.) M. Gay Lussac also states, that after making a few experiments on the new salt, the results appear ("*semblent*," showing that he trusted more to the pen than the balance,) to lead to the consequence that it is a compound of 9 cyanogen, 7 iron, and 2 potassium; so that supposing we have enough of the original ferrocyanuret of potassium to yield 14 proportions of potassium, 7 of iron, and 21 of cyanogen, then by boiling with sulphuric acid, 7 proportions of iron, + 2 potassium + 9 cyanogen fall, 12 of cyanogen go off as hydrocyanic acid, and 12 of potassium are dissolved by the sulphuric acid. Now, I prove by (*b.*) that the relation of the potassium dissolved by the sulphuric acid to that precipitated is as 3 : 1, and not as 6 : 1; by (*c.*) that the relation of the cyanogen disengaged as hydrocyanic acid is to that in the precipitate as 1 : 1, and not as 12 : 9. And the quantity of yellow salt produced in (*a.*) serves to confirm both the above results.

The theory of the subsequent conversion of the salt into Prussian blue by moistening it with dilute sulphuric acid and exposing it to air is consequently unknown. I have not yet examined the precise change which takes place with sufficient care to give an opinion: that potassa is dissolved out, and that the action of free oxygen is essential to the change, is certain.

(5.) Had I examined Gay Lussac's paper before I began my experiments, his high authority would have made me consider any further experiments on this subject as useless; but as I had finished the experiments marked Nos. 1 and 2, before I saw his paper, I was induced to repeat my experiments with redoubled care: hence the series No. 3, and hence their nearer approach to the calculated numbers. I must therefore conclude that M. Gay Lussac has operated on the salt obtained by the action of concentrated sulphuric acid on the crystals. The change in that case, according to Thomson, is so complicated that sulphurous gas, ammonia, carbonic oxide, azote, are given off. I doubt if any definite conclusions can be drawn from it.

(6.) The best proportions, therefore, of the ferrocyanuret of potassium and sulphuric acid to be used when we want hydrocyanic acid are as follows. To every 212·47 grains of the crystals dissolved in about 2 fluid ounces of water, add so much dilute sulphuric acid as shall contain 120 grains of real acid, and by conducting the distillation carefully, 41 grains of hydrocyanic acid pass off, and that I find with the first $\frac{1}{3}$rd of the water: of course water must be put into the receiver and

kept very cold. But no process for procuring a dilute solution of hydrocyanic acid, in which distillation or filtration is had recourse to, will yield an acid of uniform strength, however carefully the process may be conducted, not even, as I have proved, if the receiver be surrounded with ice. Hence the *absolute necessity* of assaying in all such processes the ultimate product, either by the nitrate of silver or the peroxide of mercury method; the first is to be preferred: we have the great advantage that any error committed in collecting, drying, and weighing, is reduced to $\frac{1}{5}$ in estimating the quantity of real acid, 100 grains of the cyanide of silver corresponding to 20·38 of hydrocyanic acid.

(7.) In addition to the very elegant application of the nitrate of silver for detecting the presence of free hydrocyanic acid in its passage as vapour from a dilute solution, or in any plant containing the acid, (thus, masticate a bitter almond, put it in a watch-glass, and cover it with a bit of glass, on the under surface of which a drop of dilute nitrate of silver is placed; in a few minutes the cyanide of silver is formed,—an experiment which may serve as a class illustration of the extreme volatility of the substance,) recommended by Mr. Barry in the London and Edinburgh Philosophical Magazine, vol. iv. p. 151. Mr. Barry has also put me in possession of a means as elegant for the testing of the presence of minute quantities of hydrochloric or sulphuric acid in hydrocyanic acid, viz. Put some of the acid on a watch-glass, add two or three drops of liquor ammoniæ, put the glass on the sand-bath, and evaporate to perfect dryness, when all ammonia and hydrocyanic acid pass off, leaving only, if any hydrochloric or sulphuric acid be present, a little hydrochlorate or sulphate of ammonia behind; a drop or two of distilled water will dissolve these, and by nitrate of silver added to one half, and nitrate of barytes to the other, the presence or absence of the above acids will be determined. If the hydrocyanic acid be quite pure, the watch-glass after evaporation is scarcely soiled, and water dissolves nothing: this method is far preferable to that by means of carbonate of lime usually recommended.

(8.) In a paper which I read to the Medico-Botanical Society, on Tuesday, Dec. 9, 1834, on the methods of assaying medicinal hydrocyanic acid, I stated that I had examined samples of the acid procured from various shops in town, and that the frightful difference of strength had induced me to make the results known, with a view of calling the attention of the medical profession to the evil. Thus, samples from Allen, Hanbury and Co. yielded 5·8 per cent.; from Apothecaries' Hall, at different times, from 2·1 to 2·6 per cent.; and from

several sources I found acid containing only 1·4 per cent. These samples I procured from the several shops personally, and asked for Scheele's strength. They were assayed within 24 hours after they were in my possession, both by the nitrate of silver and the oxide of mercury method, and the results in no cases varied more than $\frac{1}{10}$th of a grain from each other. Now it is true we have no fixed standard, and therefore it is impossible to say whether Allen and Co.'s is too strong or the others too weak; but thus much is certain, that if a medical man were pushing the exhibition of hydrocyanic acid gradually to a maximum dose, the prescriptions being carried to a shop where the acid had only 1·4 per cent., and then by some accident or other cause taken to where Allen's acid was used, a sudden and I fear a fatal increase would be the result, for more than a triple quantity would be taken. For the possibility of a fatal accident, I need only refer to the case of seven individuals near Paris being killed by a slightly increased dose, recorded in all the medical periodicals a few years since.

(9.) On the same evening I called the attention of the members of the Medico-Botanical Society to the method for procuring medical hydrocyanic acid recommended by Dr. Thomas Clarke, by cyanide of potassium and tartaric acid; a method which can now be employed by any one, since Mr. Laming has brought into the market a very pure salt. From very numerous trials, I find that the procuring of this salt, the cyanide of potassium perfectly pure, must be expensive; and I have never been able to procure it strictly in this state without using alcohol to crystallize it from: and many chemists, I find, (see Mr. Barry's paper above alluded to,) object to it, from its being so excessively deliquescent, and hence rather unmanageable, and also to the liability of this highly poisonous salt being mistaken for other white salts on their counters. This latter objection, I must say, is hypercritical: if people will be careless, there is no means of preventing mistakes, and I conceive the objection of Mr. Barry applies with tenfold force to many arrangements of a druggist's shop, where we often see tincture of opium flanked right and left by other dark tinctures; and who that has manipulated has not caught himself laying hold of, and using one acid, &c., for another when the mind is also at work?

(10.) I have made many trials as to the practicability of applying the cyanide of silver and dilute hydrochloric acid for procuring medical hydrocyanic acid. The cyanide of silver presents many advantages: it is perfectly stable, being neither affected by light nor moisture; its purity can be very easily as-

certained, and every five grains of it will yield one grain of acid. It can be procured by conducting the vapour from the process described in section (6.) of this paper, into a pint of water, holding 255 grains of nitrate of silver, washing and drying at 212°. It yields 201·6 grains of white cyanide. I should recommend that the bottle containing this salt be accompanied by a small stoppered phial with dilute hydrochloric acid of such strength, that 1 minim will exactly decompose 1 grain of the cyanide: thus, suppose one corked phial having 200 grains of cyanide with one ½-oz. stoppered bottle with hydrochloric acid of specific gravity 1·129, this would be enough to make 5 fluid ounces of dilute hydrocyanic acid of the Dublin strength, if the following formula be followed. Into a phial capable of holding rather more than 1 fluid ounce, put 40 grains of the cyanide, add 7 fluid ounces 20 minims of water, and 40 minims of the dilute hydrochloric acid; cork closely, shake several times for the first quarter of an hour, set aside to allow the chloride of silver to fall, decant the clear liquid into another bottle to be preserved for use: every fluid drachm will contain 1 grain of real hydrocyanic acid.

The only objection I had *à priori* to this process was the liability of a little free hydrochloric acid remaining in the solution, since all books echo that the presence of a minute quantity of the mineral acids very much hastens the decomposition of this acid; a statement perfectly opposite to fact, at least as far as concerns hydrochloric acid. I prepared 4 ounces of hydrocyanic acid perfectly pure by distillation off chalk; to 2 ounces I added 5 drops of hydrochloric acid; the other two ounces in another phial were left perfectly pure, both inverted and placed in a glass case so as to have diffused light during the day. After three weeks the pure acid had become quite brown, and a considerable quantity of solid deposit had formed; the other remained quite limpid and colourless, and on actual trial was found to contain $\frac{19}{20}$ths of the acid which it had at first. Mr. Barry also informed me that his fourteen years' experience led to the same result; and that, being aware of this, he adds purposely a little hydrochloric acid to all his medicinal acid. Perhaps some may object to the price of the preparation: a case containing the two bottles with 200 grains of the cyanide would leave one half profit if sold for 5*s.*; this brings an ounce of acid to 1*s.*, and where so small a quantity is used, surely this cannot be a very weighty objection, if a uniform article can be secured.

28, Golden-square, London, Dec. 12, 1834.

XVI. *On the Forms of Sulphuret of Nickel and other Substances.*

By W. H. Miller, *M.A., Fellow and Tutor of St. John's College and Professor of Mineralogy in the University of Cambridge.**

IF a sphere be described round any point in a crystal as a centre, and if radii be drawn perpendicular to the faces of the crystal, meeting the surface of the sphere in points, which we shall call the poles of the corresponding faces, the supplement of the angle between any two faces will be measured by the arc joining their poles; and if any number of faces lie in the same zone, their poles will lie in the same great circle: also, the supplement of the angle between the intersections of any face with each of two other faces will be equal to the angle contained by the great circles drawn from the pole of the former face through the poles of the two latter. Hence, a sphere having the poles of the faces of a crystal mapped upon its surface in the manner above described, or its projection, will serve to determine the form and relative positions of the faces of a crystal. This method of representing crystalline forms, the invention of which is due to Professor Neumann of Königsberg, will be used to illustrate the crystallographical notices which follow.

The degrees and minutes express the values of the arcs joining the poles of the faces, or the supplements of the angles between the faces themselves.

The symbols of the faces are expressed in the notation proposed by Mr. Whewell, in a memoir published in the Philosophical Transactions for 1825, and of which an account is given in the *Encyclopædia Metropolitana*, Art. Crystallography. The chemical notation and atomic weights are taken from the fifth edition of Dr. Turner's Chemistry.

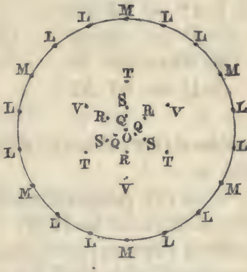
Sulphuret of Nickel. Ni + Su.—The crystals of this mineral belong to the rhombohedral system, and usually occur in very slender hexagonal prisms, which, when broken across, exhibit the faces O, Q, R, S, V: one crystal was terminated by dull faces T, forming an acute rhombohedron. In order, if possible, to determine the value of O T, the crystal was fixed to a ruler so that the faces M T were perpendicular to the plane of the ruler, and placed under a compound microscope having a fine wire stretched in the focus of the eyepiece. The ruler was then turned round in its own plane till the images of M T seen edgeways coincided successively with the wire, and the position of the ruler at each observation marked by a line drawn along its edge on a table; the angle contained

* Communicated by the Author.

by these lines, or 90° − O T, being measured, the resulting value of O T was between 48° and 49°. In the same manner the angle between the axis of the prism and the intersection of T T, was found to be nearly 61°. By a number of observations made with the reflective goniometer, O R was found equal to 20° 50′. Now, 3 tan 20° 50′ = tan 48° 47′, and ½ tan 48° 47′ = cotan 61° 17′. Hence it appears that the value of O T was measured with sufficient accuracy to be used in finding the symbol of T.

O (1, 1, 1), Q (1, 1, 0), R (1, 0, 0), S (2, 2, −1), M (1, 1, −2), T (4, 4, −5), V (−1, −1, 4), L (4, 1, −5).

O M	=	90° 0′
M M	=	60 0
M L	=	19 6
O Q	=	10 46
O R	=	20 50
O S	=	20 50
O T	=	48 47
O V	=	43 34
Q Q	=	18 38
R R	=	35 52
R S	=	20 30



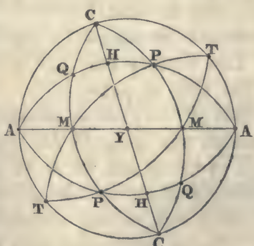
2·482 grains of the mineral weighed 2·012 grains in distilled water at 15° C. In a second experiment 2·431 grains were found to weigh 1·969 grains in water at the same temperature. The resulting specific gravities are 5·280 and 5·262.

Sulphate of Oxide of Copper and Ammonia.

$$\dot{Cu}\dddot{S} + 3\,HN\dddot{S} + 7\,\dot{H}.$$

Oblique prismatic. A (1 ; 0 ; 0), C (0 ; 0 ; 1), P (1 ; 1 ; 1), Q (1 ; −1 ; 1), H (0 ; 1 ; 1), M (1 ; 1 ; 0), T (2 ; 0 ; 1).

A T	=	41° 12½′
T C	=	64 54
C A	=	73 53½
M M	=	108 56
A M	=	35 52
P P	=	139 37
H H	=	127 39⅓
Q Q	=	140 16⅓
A Q	=	48 13⅓
C H	=	26 10⅓
A H	=	75 35



C P	=	45° 31¼′
A P	=	69 10½
C M	=	76 57
C Q	=	34 35⅓
P T	=	54 39
M T	=	52 15
A Y P	=	66 52
A Y Q	=	44 56

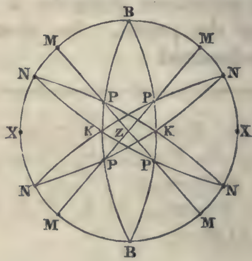
When yellow light is refracted through the faces T C, the

minimum deviation of a ray polarized in the plane T C A is about 42°.

Asparagine.—Prismatic. The number of crystals at my disposal was too small to ensure great accuracy in the determination of the angles.

B (0; 1; 0), P (1; 1; 1), M (1; 1; 0), N (2; 1; 0), K (1; 0; 1).

B M =	39°	47′
B N =	59	1
K K =	50	42
M P =	53	29
B P =	62	47
K P =	27	13
N P =	55	49
K N =	68	28
X P =	67	37



The ratio of the velocity of light in air to its velocity within the crystal is

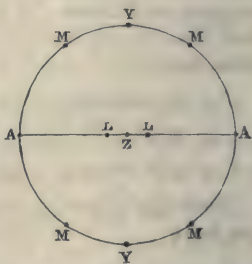
1·623, for a ray perpendicular to B B, polarized in a plane perpendicular to B B;

1·600, for a ray perpendicular to Z Z, polarized in a plane perpendicular to Z Z;

1·583, for a ray perpendicular to X X, polarized in a plane perpendicular to Z Z.

Carbazotate of Potash.—Prismatic.

M M =	89°	36′
A M =	55	12
L L =	40	20
A L =	60	50



The crystals are elongated in the direction of the axis of the zone A M, and the faces L are so small that their position cannot be accurately ascertained. The doubly refractive energy of this salt is probably greater than that of any other crystal. When yellow light is refracted through the faces M M, the minimum deviation of a ray polarized in the plane M A M is 51° 40′. Hence the ratio of the velocity of light in air to its velocity within the crystal is 1·527, for a ray in the plane M A M polarized in the same plane. For a ray traversing the crystal in the direction Y Y, and polarized in a plane perpendicular to M A M, this ratio is found to be nearly 1·95.

The cabinet of Natural History under the direction of M. Voltz, at Strassburg, contains an alloy of copper and tin in acicular crystals, the composition of which, according to the analysis of M. Roth, is expressed by the formula 2 Sn Cu. Some of these crystals, which were given me for the purpose of having their form determined, are regular six-sided prisms, cleavable with some difficulty in a direction perpendicular to the axis of the prism. No rhombohedral faces or cleavage could be detected.

XVII. *An Abstract of the essential Principles of* M. Cauchy's *View of the Undulatory Theory, leading to an Explanation of the Dispersion of Light; with Remarks. By the Rev.* Baden Powell, *M.A., F.R.S., Savilian Professor of Geometry, Oxford.*

[Continued from p. 25.]

Integration of the Equations of Motion.

In order to proceed to the integration of the equations (12.), M. Cauchy adopts the principle, (or at least one which comes to the same thing,) that whatever may be the values of the functions $\xi\ \eta\ \zeta$ which will verify those equations, they may always be developed in some serieses of algebraic functions of $x\ y\ z$, which may be considered as formed by adding together the serieses for the sine and cosine of quantities involving those functions of $x\ y\ z$, with certain arbitrary quantities $u\ v\ w$, and certain coefficients d e f g h i, functions of t. Using the symbol Σ to signify the sum of a number of such terms, we shall thus have

$$\begin{aligned} \xi &= \Sigma\{\mathrm{d} \cos(u x + v y + w z) + \mathrm{g} \sin(u x + v y + w z)\} \\ \eta &= \Sigma\{\mathrm{e} \cos(u x + v y + w z) + \mathrm{h} \sin(u x + v y + w z)\} \quad (13.) \\ \zeta &= \Sigma\{\mathrm{f} \cos(u x + v y + w z) + \mathrm{i} \sin(u x + v y + w z)\} \end{aligned}$$

Now the arbitrary quantities $u\ v\ w$ may be assumed, so that we have

$$\left.\begin{array}{l} \dfrac{u}{k} = a, \quad \dfrac{v}{k} = b, \quad \dfrac{w}{k} = c, \\ \text{and} \quad a^2 + b^2 + c^2 = 1; \end{array}\right\} \quad (14.)$$

that is, these quantities may represent the cosines of the inclinations to the three axes, of a line passing through the origin, which we will call O P.

And if we write, for abbreviation,

$$a x + b y + c z = \varrho, \quad (15.)$$

then, ϱ will be the perpendicular distance of the point $x\,y\,z$, from a plane passing through the origin whose equation is

$$a x + b y + c z = 0. \tag{16.}$$

The equations (13.) will by this notation become

$$\begin{aligned} \xi &= \Sigma[\mathrm{d}\ \cos k\varrho + \mathrm{g}\ \sin k\varrho] \\ \eta &= \Sigma[\mathrm{e}\ \cos k\varrho + \mathrm{h}\ \sin k\varrho] \\ \zeta &= \Sigma[\mathrm{f}\ \cos k\varrho + \mathrm{i}\ \sin k\varrho] \end{aligned} \tag{17.}$$

Now to determine the coefficients d e, &c., in functions of the variable t and the arbitrary constants $k\,a\,b\,c$, we may proceed as follows:

Let δ be the angle formed by r with O P,
then $\cos\delta = a\cos\alpha + b\cos\beta + c\cos\gamma$. (18.)

Also from the values of Δx, &c. (2.) joined with that of ϱ (15.) we have, taking the corresponding small increments,

$$\Delta\varrho = a\Delta x + b\Delta y + c\Delta z = r\cos\delta. \tag{19.}$$

Also we shall find by a simple trigonometrical process

$$\left.\begin{aligned} \Delta\cos k\varrho &= -2\left(\sin^2\frac{k r\cos\delta}{2}\right)\cos k\varrho \\ &\quad -\sin(k r\cos\delta)\sin k\varrho \\ &\text{And in exactly the same manner} \\ \Delta\sin k\varrho &= -2\left(\sin^2\frac{k r\cos\delta}{2}\right)\sin k\varrho \\ &\quad +\sin(k r\cos\delta)\cos k\varrho. \end{aligned}\right\} \tag{20.}$$

In order to simplify the subsequent investigation, we will in the first instance consider the sums of terms (17.) as each reduced to a single term, or take

$$\xi = \mathrm{d}\cos k\varrho + \mathrm{g}\sin k\varrho,$$

which on differentiating with respect to ϱ gives

$$\frac{d\xi}{d\varrho} = k[-\mathrm{d}\sin k\varrho + \mathrm{g}\cos k\varrho);$$

and substituting these values in the corresponding formula

$$\Delta\xi = \mathrm{d}\Delta\cos k\varrho + \mathrm{g}\,\Delta\sin k\varrho,$$

we shall find the value of that quantity, and by similar means those of the others analogous to it,

$$\left.\begin{aligned} \Delta\xi &= -2\xi\sin^2\left(\frac{k r\cos\delta}{2}\right) + \frac{\sin(k r\cos\delta)}{k}\frac{d\xi}{d\varrho} \\ \Delta\eta &= -2\eta\sin^2\left(\frac{k r\cos\delta}{2}\right) + \frac{\sin(k r\cos\delta)}{k}\frac{d\eta}{d\varrho} \\ \Delta\zeta &= -2\zeta\sin^2\left(\frac{k r\cos\delta}{2}\right) + \frac{\sin(k r\cos\delta)}{k}\frac{d\zeta}{d\varrho} \end{aligned}\right\} \tag{21.}$$

We should now have to substitute these values in the fundamental equations (12.), and thus obtain expressions involving $\xi \frac{d\xi}{d\varrho}$, &c., which would obviously extend to some length. But even without actually going through this process at length, we shall easily perceive a principle of simplification arising out of the form which we shall at once see certain parts of the expressions must take, as follows:

1st. In the forms (21.), all the terms involving $\xi\ \eta\ \zeta$ have in their coefficients the *square of the sine* of a function of δ, and these terms, when introduced as multipliers in (12.), are in the first member uncombined with any other functions of the angles $\alpha\ \beta\ \gamma\ \delta$; and in the second members are combined with the *squares of the cosines* of the angles; that is, in every case these terms are of *even dimensions.*

2ndly. All the terms involving the differential coefficients of $\xi\ \eta\ \zeta$ have, in (21.), for coefficients the *sine* of a function of δ; and these in the multiplication also, in the first member, stand uncombined with any other such function; and in the second, combined with the *squares of the cosines*; that is, in every case they are of *odd dimensions.*

Also, it appears from the original construction and from (18.) that the cosines of $\alpha\ \beta\ \gamma\ \delta$ are all positive or all negative together.

Now, in taking the sum of a number of terms (indicated by the symbol S), it is evident in the former of the above two cases that all those terms will be positive whatever be the signs of the cosines. In the second case, for the same reason, the terms will be positive or negative according to the change of sign in the cosines.

If, then, we suppose in such a sum, half the terms corresponding to positive, and half to negative values of the cosines, we shall find that *the coefficients of all the terms in the second case will disappear*, whilst in the first case they will remain. The whole expression will thus be reduced to the terms involving $\xi\ \eta\ \zeta$ only.

This last supposition is precisely that of a physical condition which we shall have no difficulty in allowing, viz. that in the state of equilibrium the masses of the molecules $m\ m'\ m''$, &c., are two and two equal, and distributed symmetrically on each side of the molecule m on straight lines passing through m. This obviously gives the cosines for half the molecules positive, and for half negative.

In such a case then we shall have the general equations of motion reduced to a considerably simplified form; or, for ab-

breviation, writing the sums of the coefficients derived from those terms of (12.) which involve $\cos^2 \alpha$, $\cos^2 \beta$, $\cos^2 \gamma$, respectively L, M, N; and those which involve $\cos \beta \cos \gamma$, $\cos \gamma \cos \alpha$, $\cos \alpha \cos \beta$, respectively P, Q, R, those equations are reduced to the following:

$$\left.\begin{aligned} \frac{d^2 \xi}{d t^2} &= -[\mathrm{L}\xi + \mathrm{R}\eta + \mathrm{Q}\xi] \\ \frac{d^2 \eta}{d t^2} &= -[\mathrm{R}\xi + \mathrm{M}\eta + \mathrm{P}\zeta] \\ \frac{d^2 \zeta}{d t^2} &= -[\mathrm{Q}\xi + \mathrm{P}\eta + \mathrm{N}\zeta] \end{aligned}\right\} \qquad (22.)$$

These equations enable us at the end of the time t, to determine the three functions $\xi\ \eta\ \zeta$; which is, in fact, done, if we have determined the six functions d e f g h i; and this we can effect by means of the *initial values* of these functions, and their differential coefficients with respect to t. Writing these initial values of the functions by subjoining (o), and those of their differential coefficients by subjoining (1.), we shall have by the formula (17.), supposed reduced to a single term,

$$\left.\begin{aligned} \xi_0 &= \mathrm{d}_0 \cos k\varrho + \mathrm{g}_0 \sin k\varrho \\ \eta_0 &= \mathrm{e}_0 \cos k\varrho + \mathrm{k}_0 \sin k\varrho \\ \zeta_0 &= \mathrm{f}_0 \cos k\varrho + \mathrm{i}_0 \sin k\varrho \\ \xi_1 &= \mathrm{d}_1 \cos k\varrho + \mathrm{g}_1 \sin k\varrho \\ \eta_1 &= \mathrm{e}_1 \cos k\varrho + \mathrm{k}_1 \sin k\varrho \\ \zeta_1 &= \mathrm{f}_1 \cos k\varrho + \mathrm{i}_1 \sin k\varrho \end{aligned}\right\} \qquad (23.)$$

In order, by means of these values corresponding to $t = 0$, to deduce those corresponding to any value of t, we must proceed to the following considerations relative to the coefficients.

Let the arbitrary quantities A B C be assumed as the cosines of the angles which a certain line O A through the origin forms with the positive semiaxes; or in other words, so that we have

$$\mathrm{A}^2 + \mathrm{B}^2 + \mathrm{C}^2 = 1 \qquad (24.)$$

and the line O A is represented by the equations

$$\frac{x}{\mathrm{A}} = \frac{y}{\mathrm{B}} = \frac{z}{\mathrm{C}}, \qquad (25.)$$

Also, if we suppose

$$8 = \mathrm{A}\,\xi + \mathrm{B}\,\eta + \mathrm{C}\,\zeta, \qquad (26.)$$

the value of 8 will give the displacement of the molecule m in a direction parallel to the line OA, and positive or negative according to the direction of that line.

Again, if the quantities A B C be so chosen that on multiplying the first term of each member of the equations (22.) by A, the second by B, and the third by C, we have

$$\frac{LA+RB+QC}{A}=\frac{RA+MB+PC}{B}=\frac{QA+PB+NC}{C} \quad (27.)$$

and write these equal to s^2, then, on differentiating the equation (26.), and substituting the values from equation (22.), we shall find the second differential coefficient to be the remarkable form

$$\frac{d^2 s}{d t^2} = -s^2 s. \quad (28.)$$

From (27.) it is evident that we have three values of s^2 corresponding to three systems of values of the ratios $\frac{B}{A}, \frac{C}{A}$; and consequently there are three straight lines with either of which the line O A may coincide; and the same equations enable us to determine these lines, for they evidently coincide in form with those mentioned in the preliminary article. We can deduce the same equation of the third degree, which for reference we will call (29.); and consequently the three lines OA' OA'' OA''' are identified with the three axes of the surface of the second degree represented by the equation there assumed, involving as coefficients the quantities L M N, &c., and which we will call (30.). If it be an ellipsoid, the three values of s^2 are equal to the squares of the three semiaxes of the ellipsoid.

These considerations then enable us to assign the displacement of m at the end of the time t, in directions parallel to three determinate lines at right angles. Let these three displacements be expressed by accenting the letters in equation (26.), or let us suppose

$$\left.\begin{aligned} s' &= A'\xi + B'\eta + C'\zeta \\ s'' &= A''\xi + B''\eta + C''\zeta \\ s''' &= A'''\xi + B'''\eta + C'''\zeta \end{aligned}\right\} \quad (31.)$$

In each set of the coefficients the relation (24.) holds good; also, since the lines are at right angles, we have

$$\left.\begin{aligned} A'A'' + B'B'' + C'C'' &= 0 \\ A''A''' + B''B''' + C''C''' &= 0 \\ A'A''' + B'B''' + C'C''' &= 0 \end{aligned}\right\} \quad (32.)$$

Hence we deduce from (31.)

$$\left.\begin{aligned} \xi &= A's' + A''s'' + A'''s''' \\ \eta &= B's' + B''s'' + B'''s''' \\ \zeta &= C's' + C''s'' + C'''s''' \end{aligned}\right\} \quad (33.)$$

Now, writing $\mathfrak{s}_0\ \mathfrak{s}_1$ for the initial values of $\mathfrak{s}$ and $\frac{d\mathfrak{s}}{dt}$, we have

$$\mathfrak{s}_0 = A\xi_0 + B\eta_0 + C\zeta_0 \qquad (34.)$$

$$\mathfrak{s}_1 = A\xi_1 + B\eta_1 + C\zeta_1; \qquad (35.)$$

or, substituting the values of $\xi_0\ \xi_1$, &c., from (23.), these forms become

$$\mathfrak{s}_0 = [d_0 A + e_0 B + f_0 C] \cos k\varrho + [g_0 A + h_0 B + i_0 C] \sin k\varrho = \varpi(\varrho) \qquad (36.)$$

$$\mathfrak{s}_1 = [d_1 A + e_1 B + f_1 C] \cos k\varrho + [g_1 A + h_1 B + i_1 C] \sin k\varrho = \Pi(\varrho), \qquad (37.)$$

using the last symbols to designate the forms of these functions of ϱ.

The form of the expression (28.) shows us at once that its integral must be a trigonometrical function, which it will easily be seen must take the following form, involving as coefficients the initial values

$$\mathfrak{s} = \mathfrak{s}_0 \cos st + \mathfrak{s}_1 \frac{\sin st}{s}, \qquad (38.)$$

or, what is the same thing,

$$\mathfrak{s} = \mathfrak{s}_0 \cos st + \mathfrak{s}_1 \int_0^t \cos st\, dt. \qquad (39.)$$

If we here substitute the values of $\mathfrak{s}_0\ \mathfrak{s}_1$ and the trigonometrical values of the resulting products, and also write

$$\frac{s}{k} = \Omega,$$

we shall at length deduce an expression, which, in comparison with equations (36.) (37.), may, by the same notation, be expressed thus, (carefully observing that no greater generality is implied than belongs to (38.) and (39.)):

$$\mathfrak{s} = \left\{ \begin{array}{l} \dfrac{\varpi(\varrho + \Omega t) + \varpi(\varrho - \Omega t)}{2} \\ + \displaystyle\int_0^t \frac{\Pi(\varrho + \Omega t) + \Pi(\varrho - \Omega t)}{2}\, dt, \end{array} \right. \qquad (40.)$$

the form being the same for each of the values $\mathfrak{s}'\ \mathfrak{s}''\ \mathfrak{s}'''$ corresponding to the three positive values of s^2, involving respectively $\Omega'\ \Omega''\ \Omega'''$ and $A'\ A''\ A'''$, &c. If these values of $\mathfrak{s}'$, &c., be substituted in equation (33.), we have $\xi\ \eta\ \zeta$ in functions of ϱ and t, which satisfy the two conditions of the values ξ_0, &c., when $t = 0$, and of the equations (22.) for any value of t.

Also the *velocity* ω of the molecule at the end of any time t

in the directions of the axes, and of the three lines o A respectively, will be

$$\frac{d\xi}{dt}\ \frac{d\eta}{dt}\ \frac{d}{dt} \text{ and } \frac{ds''}{dt}\ \frac{ds''}{dt}\ \frac{ds'''}{dt},$$

and, we have also

$$w^2 = \left(\frac{d\xi}{dt}\right)^2 + \left(\frac{d\eta}{dt}\right)^2 + \left(\frac{d\zeta}{dt}\right)^2 = \left(\frac{ds'}{dt}\right)^2 + \left(\frac{ds''}{dt}\right)^2 + \left(\frac{ds'''}{dt}\right)^2 \qquad (41.)$$

[To be continued.]

XVIII. *On the Existence of Titanic Acid in Hessian Crucibles.* *By* Mr. R. H. Brett *and* Mr. Golding Bird.

To the Editors of the Philosophical Magazine and Journal.

Gentlemen,

WHILE repeating some experiments lately published on the presence of titanium in organic matter, especially in the renal capsules*, we observed that when an alkaline carbonate was exposed to heat in Hessian crucibles, a fused mass was obtained, which was yellow while hot, but white and opake when cold; on dissolving this fused mass in dilute hydrochloric acid and mixing the solution with hydrosulphuret of ammonia, a deep olive green precipitate was obtained, which, when dried and ignited, yielded a white powder, insoluble in the dilute acids. These reactions so exactly resembling those yielded by titaniferous substances, we were induced to suspect the presence of titanium in the clay of which the crucibles were formed. To determine this with accuracy we undertook an analytical examination of the several varieties of Hessian crucibles usually met with, and we found them all to consist of (in variable proportions) silicic acid, titanic acid, alumina, and peroxide of iron, with traces of magnesia and manganese, and occasionally of lime.

The quantity of titanic acid present differed considerably in different specimens, in some not amounting to more than $3\frac{1}{2}$ or 4 per cent., and in some few even to as much as 25 or 30: it was exceedingly rare to meet with so much as 25 per cent.; those crucibles that contained that quantity were generally small, very thin, brittle, and studded with numerous black semimetallic-looking specks. The quantity of peroxide of iron present was small compared to that of titanic acid, and they were by no means in the proportions in which they exist either in the iserine or in the menachanite, to the presence of which

* See our last volume, p. 398.—Edit.

forms of titaniferous sand we at first were inclined to believe the presence of titanium was owing, this opinion appearing to be corroborated by our noticing that in those crucibles in which the black specks (above referred to) were most numerous, the quantity of titanium appeared to be the greatest. The source of that metal in these crucibles must still remain a question.

We subjoin an outline of the process we followed in the analysis of these crucibles, as we believe that the (hitherto unlooked for) presence of titanium in these articles of chemical research to be of some importance in analytical chemistry.

1. A portion of a crucible was reduced to fine powder in an agate mortar, then carefully mingled with three times its weight of carbonate of potass in a platinum crucible; the latter was then exposed to a red heat until all effervescence had ceased; the heat was then raised to whiteness so as to ensure perfect decomposition of the silicious body. The fused mass while hot was yellow; on cooling, however, it became greyish and opake.

2. The crucible being wiped from the adhering ashes was placed in a glass cylinder, covered with distilled water; hydrochloric acid was then poured in and the cylinder closed with a watch-glass. After some hours the fused mass was entirely *dissolved* or loosened out of the crucible; the latter was removed, rinsed with distilled water, the washings being added to the solution, which was nearly limpid, (a few light flakes of silicic acid were in suspension,) a little nitric acid was added, and the whole evaporated to dryness; the residue was diffused through a considerable quantity of distilled water and thrown on a filter: the silicic acid thus separated was washed with distilled water until the last portions of fluid ceased to affect nitrate of silver; it was then dried, ignited, and weighed.

3. The filtered liquor with the washings was evaporated over a steam-bath to half a pint, a few grains of sugar added (to reduce the manganese to protoxide and thus render it soluble in an ammoniacal salt), and ammonia poured in to supersaturation: a copious gelatinous precipitate fell, which was collected on a filter, washed with a dilute solution of muriate of ammonia, and thoroughly dried on a sand-bath.

4. The dried precipitate thus obtained, consisting of titanic acid, alumina, and peroxide of iron, was boiled in hydrochloric acid, which dissolved the alumina and iron; the insoluble titanic acid was then washed, ignited, and weighed.

5. The acid solution of alumina and iron was mixed with an excess of caustic potass and boiled: the peroxide of iron thus separated was then ignited and weighed.

6. The alumina was next obtained by boiling the alkaline solution with an excess of muriate of ammonia for some time: the resulting gelatinous precipitate was washed, ignited, and weighed.

7. The liquor (3.) from which the titanic acid, alumina, and peroxide of iron were separated, contained traces of magnesia and manganese.

The results obtained by examining several specimens, differed very considerably, as may be seen by comparing together the following results of four analyses:

	1st.	2nd.	3rd.	4th.
Silicic acid	75·1	70·0	68·0	66·0
Titanic acid	3·5	5·3	8·0	21·0
Alumina	15·0	18·7	18·0	8·0
Peroxide of iron	2·8	3·0	5·0	4·0
Magnesia	1·4	0·6	0·3	traces
Oxide of manganese	·8	1·2		
	98·6	98·8	99·3	99·0
Loss	1·4	1·2	·7	1·
	100·	100·	100·	100·

In a very few specimens we have found the titanic acid to be present in very minute quantities, and in one or two only we could not succeed in detecting any. It is a very difficult matter to free the titanic acid from the peroxide of iron, the last traces of which adhere exceedingly obstinately to the acid; the process recommended by Berzelius, viz. adding tartaric acid to the acid solution of the mixed oxides and the subsequent precipitation of the iron by hydrosulphuret of ammonia, by no means succeeding perfectly. The use of oxalic acid for the purpose of precipitating the titanium and leaving the iron in solution is not more efficient, as the precipitate is found to be contaminated with a considerable quantity of peroxide of iron. The following is the process we prefer for the purpose of obtaining the titanium, free from iron. Ignite a mixture of carbonate of potass and powdered Hessian crucibles; digest the mass thus obtained in warm water for some time: this aqueous solution yields a very slight grass-green tinge with hydrosulphuret of ammonia. Dissolve the portion insoluble in water in hydrochloric acid, with the assistance of a gentle heat; dilute and filter the acid solution and wash the residue on the filter; when the acid has almost entirely passed the filter, the washings become opaline. The filtered fluid is then to be nearly neutralized with ammonia, and hydrosulphuret of ammonia added: a deep green precipitate falls, which is to be collected on a filter and washed with a di-

lute solution of muriate of ammonia. This precipitate is almost black in the mass, but when spread over the surface of white porcelain or paper, it appears of a fine sap-green; by exposure to the air it becomes nearly white on the surface, which discoloration speedily extends to some depth, (if all the hydrosulphuret has not been washed away, this change does not take place until after some time); it is then to be dried on a sand-bath and digested in weak hydrochloric acid, by which almost all the sulphuret of iron is removed; the insoluble portion is then to be again dried and ignited, in a platinum capsule over the circular-wick spirit-lamp (or if in considerable quantity, on a platinum tray in a small muffle); a cream-coloured powder is thus obtained, still containing a minute portion of iron, which may be got rid of by mixing it with muriate of ammonia, and exposing it for some time to a temperature below ignition. The titanic acid thus procured is tolerably pure.

In conclusion we would wish to remark that titanium appears to be more generally diffused through the mineral kingdom than is generally stated (in chemical works), as appears particularly from the following passage in Thénard's *Traité de Chimie*: "Le deutoxide de fer se rencontre sous forme de sables. Ces sables contiennent ordinairement de l'oxide de titane ou de l'oxide de chrome en combinaison avec l'oxide de fer. M. Descotils a retiré jusqu'à 30 parties de titane de 100 parties de sables ferrugineux de Saint-Quay, département des Côtes du Nord. M. Robiquet l'a rencontré dans le deutoxide de fer des roches steatiteuses de la Corse."

Guy's Hospital, Dec. 26th, 1834.

XIX. *On some Elementary Applications of* Abel's *Theorem.* *By* J. W. Lubbock, *Esq., V.P. & Treas. R.S.**

ABEL, in the third volume of Crelle's Journal, gave a theorem, which constitutes one of the most remarkable discoveries ever made in analysis, by which the methods of finding the sum of certain definite integrals were greatly extended. Cut off in the prime of life†, it was not given to the mathematician of Christiania to pursue the career which is opened to analysts by the theorem in question, or to illustrate its application by examples. This has been done to a certain extent by Legendre in the third Supplement of his work entitled *Théorie des Fonctions Elliptiques* ‡. As, however, no notice of this theorem has yet appeared in any work in the En-

* Communicated by the Author.

† [See Phil. Mag. and Annals, N.S. vol. vii. p. 77.—Edit.]

‡ [See Lond. and Edinb. Phil. Mag., vol. iv. p. 143.—Edit.]

glish language, to my knowledge, the following examples of its application to some of the simplest cases which can be proposed are here offered, with a view of attracting attention to an important analytical discovery*. Legendre has applied Abel's theorem to the integral

$$\int \frac{d\,x}{\sqrt{1-x^5}}.$$

The subject of the first example here detailed is the integral

$$\int \frac{d\,x}{\sqrt{1-x^3}},$$

which may, in fact, be reduced to an elliptic integral of the first kind; and thus, through the well-known integral due to Euler, a confirmation may be easily obtained, in this instance, of the result found by the method of Abel.

The subject of the second example is

$$\int \frac{d\,x}{\sqrt{1+x^n}},$$

which cannot in general be reduced to an elliptic integral. Here I have chosen for the equations of condition between the limits x_1, x_2, x_3, &c., equations similar to those employed by Mr. Talbot in his paper on the sum of three arcs of the equilateral hyperbola†. I have also applied the method of Abel to the integral

$$\int \frac{x^2 d\,x}{\sqrt{1+x^4}},$$

and deduced therefrom the theorem given by Mr. Talbot in the paper to which I have referred.

The theorem of Abel is as follows:

"Soit $\phi\, x$ une fonction entière de x, décomposée d'une manière quelconque en deux facteurs entiers $\phi_1\, x$ et $\phi_2\, x$, ensorte que $\phi\, x = \phi_1\, x . \phi_2\, x$. Soit $f x$ une autre fonction entière quelconque et

$$\psi\, x = \int \frac{f x\, d\,x}{(x-\alpha)\sqrt{(\phi\, x)}},$$

où α est une quantité constante quelconque. Désignons par $a_0, a_1, a_2, \ldots$; $c_0, c_1, c_2, \ldots$ des quantités quelconques dont l'une au moins soit variable. Celà posé, si l'on fait

* Professor Jacobi says, "Wir halten es, wie es in einfacher Gestalt ohne Apparat von Calcul den tiefsten und umfassendsten mathematischen Gedanken ausspricht, für die grösste mathematische Entdeckung unsrer Zeit, obgleich erst eine künftige, vielleicht späte, grosse Arbeit ihre ganze Bedeutung aufweisen kann.—*Crelle's Journal*, vol. viii. p. 415.

† [A notice of Mr. Talbot's paper will be found in Lond. and Edinb. Phil. Mag. vol. iv. p. 225.—Edit.]

$$(a_0+a_1x+a_2x^2+\ldots\ldots+a_nx^n)^2\,.\,\phi_1x$$
$$-(c_0+c_1x+c_2x^2+\ldots\ldots+c_mx^m)^2.\,\phi_2x$$
$$=A\,(x-x_1)\,(x-x_2)(x-x_3)\ldots\ldots(x-x_\mu),$$

où A ne dépend pas de x, je dis qu'on aura

$$\varepsilon_1\psi x_1+\varepsilon_2\psi x_2+\varepsilon_3\psi x_3.+\ \ldots\ldots\ +\varepsilon_\mu\psi x_\mu$$

$$=\frac{f\alpha}{\sqrt{\phi\alpha}}.\log\left\{\frac{(a_0+a_1\alpha+\ldots+a_n\alpha^n)\sqrt{(\phi_1\alpha)}+(c_0+c_1\alpha+\ldots+c_m\alpha^m)\sqrt{(\phi_2\alpha)}}{(a_0+a_1x+\ldots+\alpha_n\alpha^n)\sqrt{(\phi_1\alpha)}-(c_0+c_1\alpha+\ \ +c_m\alpha^m)\sqrt{(\phi_2\alpha)}}\right\}$$
$$+r+C$$

où C est une quantité constante et r le coëfficient de $\frac{1}{x}$ dans le développement de la fonction

$$\frac{fx}{(x-\alpha)\sqrt{\phi x}}.\log\left\{\frac{(a_0+a_1x+\ldots+a_nx^n)\sqrt{(\phi_1x)}+(c_1+c_1x+\ldots+c_mx^m)\sqrt{(\phi_2x)}}{(a_0+a_1x+\ldots+a_nx^n)\sqrt{(\phi_1x)}-(c_0+c_1x+\ldots+c_mx^m)\sqrt{(\phi_2x)}}\right\},$$

suivant les puissances descendantes de x. Les quantités ε_1, ε_2, ... ε_μ sont égales à $+1$ ou à -1, et leurs valeurs dépendent de celles des quantités x_1, x_2 ...... x_μ." ....

Suppose generally,

$$\theta x=a_0+a_1x+a_2x^2\ \ldots\ldots\ +a_nx^n$$
$$\theta_1x=c_0+c_1x+c_2x^2\ \ldots\ldots\ +c_mx^m.$$

The values of ε_1, ε_2, ε_3 ...... ε_μ are not arbitrary, they depend upon the magnitude of x_1, x_2 ...... x_μ, and this is determined by the equation

$$\theta x\sqrt{\phi_1x}=\varepsilon\,\theta_1x\sqrt{\phi_2x}.$$

Moreover, if fx is divisible by $x-\alpha$, $f\alpha=0$; and if $(fx)^2$ is of less dimensions than ϕx, r vanishes, and

$$\varepsilon_1\psi x_1+\varepsilon_2\psi x_2\ \ldots\ldots\ldots\ +\varepsilon_\mu\psi x_\mu=C.$$

In the following examples A is made equal to unity, which is allowable.

It is intended here first to apply the theorem to the integral

$$\int\frac{dx}{\sqrt{1-x^3}}=\psi x\qquad 1-x^3=(1+x+x^2)(1-x).$$

In this case $\phi_1x=1+x+x^2$, $\quad\phi_2x=1-x$

$$1+x+x^2-c^2(1-x)=(x-x_1)(x-x_2)\quad\theta x=1\qquad\theta_2x=c.$$

Equating the coefficients of powers of x,

$$1 - c^3 = x_1 x_2$$

$$1 + c^3 = -x_1 - x_2$$

$$2 = x_1 x_2 - x_1 - x_2 \qquad 3 = (1-x_1)(1-x_2)$$

$$x_1 = \frac{2+x_2}{x_2-1}$$

When $x_2 = 1 \qquad x_1 = -$ infinity

$$x_2 = \frac{1}{2} \qquad x_1 = -5$$

$$x_2 = \frac{1}{3} \qquad x_1 = -\frac{7}{2}.$$

$$\int \frac{dx}{\sqrt{1-x^3}} = x + \frac{x^4}{2.4} + \frac{1.3\,x^7}{2.4.7} + \frac{1.3.5\,x^{10}}{2.4.6.10} +, \&c.$$

Making $x = \frac{1}{2}$ this series gives $\psi x = \cdot 508264$

$x = \frac{1}{3}$ .... $\psi x = \cdot 334901.$

Making $x = -y$

$$\int \frac{dx}{\sqrt{1-x^3}} = -\int \frac{dy}{\sqrt{1+y^3}}.$$

Now, let $\frac{1}{1+y^3} = u$

$$-\int \frac{dy}{\sqrt{1+y^3}} = 2\left\{ u^{\frac{1}{6}} + \frac{2}{3.7}u^{\frac{7}{6}} + \frac{2.5}{3.6.13}u^{\frac{13}{6}} +, \&c. \right\}$$

If $\psi' \frac{1}{0}$ denote the integral

$$\int \frac{dy}{\sqrt{1+y^3}}$$

taken from $y = 0$ to $y = \infty$, the preceding series gives when

$$x = -5, \quad u = \frac{1}{126}, \quad \psi \alpha = \cdot 893917 - \psi' \frac{1}{0}$$

$$x = -\frac{7}{2}, \quad u = \frac{8}{351}, \quad \psi x = 1\cdot 06728 - \psi' \frac{1}{0}.$$

By the theorem of Abel, if x_1 and x_2 are connected by the equation

$$x_1 = \frac{2+x_2}{x_2-1}. \quad \text{(See line 4 above.)}$$

$$\varepsilon_1 \psi x_1 + \varepsilon_2 \psi_2 = \text{constant, or}$$

$$\varepsilon_1 \int_0^{x_1} \frac{dx}{\sqrt{1-x^3}} + \varepsilon_2 \int_0^{x_2} \frac{dx}{\sqrt{1-x^3}} = \text{constant.}$$

In this example $\varepsilon_1 = +1$, $\varepsilon_2 = +1$ $\psi x_1 + \psi x_2 = \psi 1 - \psi'_{\frac{1}{0}}$.

By the known properties of the function Γ, (see *Théorie des Fonctions Elliptiques*, vol. ii. p. 417,)

$$\int x^{p-1} dx \, (1-x)^{q-1} = \frac{\Gamma p \, \Gamma q}{\Gamma(p+q)}$$

$$\psi_1 = \frac{1}{3} \frac{\Gamma \frac{1}{3} \Gamma \frac{1}{2}}{\Gamma \frac{5}{6}} = \frac{5}{6} \pi^{\frac{1}{2}} \frac{\Gamma(\frac{4}{3})}{\Gamma(\frac{11}{6})}$$

$$\log \pi^{\frac{1}{2}} = 0{\cdot}2485749 \qquad \log \Gamma\left(\frac{11}{6}\right) = 9{\cdot}9734262$$

$$\log \Gamma\left(\frac{4}{3}\right)^* = 9{\cdot}9508435 \qquad \log 6 = 0{\cdot}7781513$$

$$\log 5 = 0{\cdot}6989700 \qquad\qquad 0{\cdot}755775$$

$$0{\cdot}8983884$$
$$0{\cdot}7515775$$

$$\log \psi_1 = 0{\cdot}1468109$$
$$\psi_1 = 1{\cdot}402202$$

$$\psi'_{\frac{1}{0}} = \frac{1}{\cos 60^\circ} \psi_1 = 2\psi_1 = 2{\cdot}804405.$$

It will now be seen that the numerical values of the integrals ϕx_1, ϕx_2 verify the equation

$$\psi x_1 + \psi x_2 = \psi_1 - \psi'_{\frac{1}{0}},$$

for

$$\cdot 508264 + \cdot 893917 - \psi'_{\frac{1}{0}} = \psi_1 - \psi'_{\frac{1}{0}}$$

$$\cdot 508264 + \cdot 893917 = \psi_1$$

$$\cdot 334901 + 1{\cdot}06728 = \psi_1.$$

The preceding results may easily be shown to be in accordance with the known theory of elliptic integrals by putting for x

$$1 - \frac{\sqrt{3}}{\tan^2 \frac{1}{2} \phi}. \quad \text{(See Legendre, vol. ii. p. 381.)}$$

$$\int \frac{dx}{\sqrt{1-x^3}} = (3)^{\frac{1}{4}} \int \frac{d\phi}{\sqrt{1 - \sqrt{3} \sin^2 \phi}}.$$

The equation

$$3 = (1-x_1)(1-x_2) \text{ gives}$$

---

* $\frac{4}{3} = 1{\cdot}33333$ and $\frac{11}{8} = 1{\cdot}83333$, &c. (See the Table of the values of $\log \Gamma a$, *Théorie des Fonctions Elliptiques*, vol. ii. p. 493.)

$$\tan^2 \frac{\phi_1}{2} \tan^2 \frac{\phi_2}{2} = 1$$

$$\phi_1 + \phi_2 = \pi.$$

I shall now consider the integral

$$\int \frac{dx}{\sqrt{1+x^n}},$$

which cannot, except in certain cases, be reduced to an elliptic integral.

Suppose

$$\sqrt{1+x^n} = \sqrt{\phi\, x}, \quad 1+x^n = \phi_1 x, \quad \phi_2 x = 1$$

$$\theta\, x = 1, \quad \theta_2\, x = 1 + c_1\, x$$

$$1 + x^n - (1 + c_1 x)^2 = x\left(x^{n-1} - \frac{x_1^2\, x_2^2\, x_3^2 \ldots x^2_{n-1} x}{4} \pm x_1\, x_2\, x_3 \ldots x_{n-1}\right),$$

the upper sign to be taken if n is an uneven number, and the lower if x is even, $x_1, x_2, x_3 \ldots x_{n-1}$ being the roots of the equation $\quad x^{n-1} - Px + Q = 0$

$$P = \frac{x_1^2\, x_2^2\, x_3^2 \ldots x^2_{n-1}}{4},$$

$$x_1 + x_2 + x_3 \ldots\ldots\ldots + x_{n-1} = 0$$

together with the other conditions implied by the nature of the equation $\quad x^{n-1} - Px + Q = 0$

$$c_1 = \mp \frac{x_1\, x_2\, x_3 \ldots x_{n-1}}{2}.$$

$x_1, x_2, x_3 \ldots x_{n-1}$, being subject to the above condition

$$\varepsilon_1 \int_0^{x_1} \frac{dx}{\sqrt{1+x^n}} + \varepsilon_2 \int_0^{x_2} \frac{dx}{\sqrt{1+x^n}} \ldots\ldots + \varepsilon_{n-1} \int_0^{x_{n-1}} \frac{dx}{\sqrt{1+x^n}}$$
$$= \text{constant}.$$

Also,

$$\varepsilon^1 \int_0^{x_1} \frac{x^2\, dx}{\sqrt{1+x^n}} + \varepsilon_2 \int_0^{x_2} \frac{x^2\, dx}{\sqrt{1+x^n}} \ldots\ldots + \varepsilon_{n-1} \int_0^{x_{n-1}} \frac{x^2\, dx}{\sqrt{1+x^n}}$$
$$= \text{constant}.$$

$\vdash$ coefficient of $\dfrac{1}{x}$ in the development of

$$\frac{x^2}{\sqrt{1+x^n}} \log. \left\{ \frac{1 + \dfrac{1 + c_1 x}{\sqrt{1+x^n}}}{1 - \dfrac{1 + c_1 x}{\sqrt{1+x^n}}} \right\}$$

according to descending powers of x.

Suppose $n = 4$, then the equation

$$x^{n-1} - Px + Q = 0 \text{ has only three roots, } x_1, x_2, x_3$$

$$x_1 + x_2 + x_3 = 0$$

$$x_1 x_2 + x_2 x_3 + x_1 x_3 = -\frac{x_1^2 x_2^2 x_3^2}{4}$$

or, $$\frac{1}{x_3} + \frac{1}{x_2} + \frac{1}{x_1} = -\frac{x_1 x_2 x_3}{4}.$$

These are Mr. Talbot's equations of condition in the paper to which I have referred.

Since $$\varepsilon_1 \sqrt{1 + x_1^4} = 1 + c_1 x_1$$

$$c_1 = \varepsilon_1 \sqrt{1 + x_1^4} - 1 = \frac{x_1 x_2 x_3}{2}$$

$$\frac{x_2 x_3}{2} = \frac{\varepsilon_1 \sqrt{1 + x_1^4} - 1}{x_1^2}$$

$$x_2 + x_3 = -x$$

If $x_2 x_3 = 2A$

x_2 and x_3 are found by solving the quadratic

$$x^2 - x x_1 + 2A = 0$$

when x_1 is given.

Making $x_1 = 2$ $\qquad \frac{1}{x_1} = \cdot 5 \qquad \varepsilon_1 = -1$

I find $x_2 = -2\cdot 88721 \qquad \frac{1}{x_2} = -\cdot 346355 \qquad \varepsilon_2 = +1$

$x_3 = \cdot 88721 \qquad \frac{1}{x_3} = 1\cdot 12713 \qquad \varepsilon_3 = -1$

Making $x_1 = 5$ $\qquad \frac{1}{x_1} = \cdot 2 \qquad \varepsilon_1 = -1$

I find $x_2 = -5\cdot 38645 \qquad \frac{1}{x_2} = -\cdot 185651 \qquad \varepsilon_2 = +1$

$x_3 = \cdot 38645 \qquad \frac{1}{x_3} = -2\cdot 58765 \qquad \varepsilon_3 = -1$

In order to obtain convergent expressions for the integral required, I make

$$\frac{1}{1 + x^4} = u, \text{ then}$$

$$\int \frac{dx}{\sqrt{1 + x^4}} = u^{\frac{1}{4}} + \frac{3}{4.5} u^{\frac{5}{4}} + \frac{3.7}{4.8.9} u^{\frac{9}{4}} + \frac{3.7.11}{4.8.12.13} u^{\frac{13}{4}} + \&c.$$

If this series be called U, the integral

$$\int \frac{dx}{\sqrt{1+x^4}} = \psi' \frac{1}{0} - U$$

I find from this series for the values of the integral

from $x = 0$ to $x = 2$, $\quad \psi'\frac{1}{0} - \cdot 49695$

............$x = 0$ to $x = -2{\cdot}88721$, $\quad -\psi'\frac{1}{0} + \cdot 34586$

............$x = 0$ to $x = 5$, $\quad \psi'\frac{1}{0} - \cdot 199968$

............$x = 0$ to $x = -5{\cdot}38645$, $\quad -\psi'\frac{1}{0} + \cdot 185628$

In order to have a convergent series for the value of the integral from $x = 0$ to $x = \cdot 88721$, I make

$$\frac{x^4}{1+x^4} = u$$

$$\int \frac{dx}{\sqrt{1+x^4}} = u^{\frac{1}{4}} + \frac{3u^{\frac{5}{4}}}{4.5} + \frac{3.7u^{\frac{9}{4}}}{4.8.9} + \frac{3.7.11\,u^{\frac{13}{4}}}{4.8.12.13} + \&c.$$

and I find for the integral in question, the number $+\cdot 84288$.

The integral from $x = 0$ to $x = \cdot 38645$ may be found at once from the expression

$$\int \frac{dx}{\sqrt{1+x^4}} = x - \frac{x^5}{2.5} + \frac{1.3\,x^9}{2.4.9} - \frac{1.3.5\,x^{13}}{2.4.6.13} + \&c.$$

and I obtain for this integral the number $+ \cdot 38561$.

It appears in this case that the constant on the right hand side of the equation equals $-2\,\psi'\frac{1}{0}$, and

$$\cdot 49695 + \cdot 34586 - \cdot 84288 = 0 \text{ nearly*}$$
$$\cdot 19968 + \cdot 185624 - \cdot 38561 = 0 \text{ ———}$$

according to the general theorem. It may be proper to mention, that the transformations adopted in order to procure convergent series for the integrals required, are all taken from Legendre's work.

The equations of condition between the quantities x_1, x_2, x_3 ...... &c., may be varied to an almost indefinite extent: those which I have adopted in the last example are the same which were used by Mr. Talbot, and through which he obtained a

* The theorem is of course rigorous, but it can only be verified approximately in numerical examples.

theorem relative to the sum of three arcs of an equilateral hyperbola.

The coefficient of $\frac{1}{x}$ in the development of

$$\frac{x^2}{\sqrt{1+x^4}} \log \left\{ \frac{1 + \frac{1+c_1 x}{\sqrt{1+x^4}}}{1 - \frac{1+c_1 x}{\sqrt{1+x^4}}} \right\}$$

= coefficient of $\frac{1}{x}$ in the development of

$$\frac{x^2}{x^2}\left\{1-\frac{1}{2x^4}+\&c.\right\} \log \left\{ \frac{1+\left\{1+\frac{x_1 x_2 x_3 x}{2}\right\}\left\{1-\frac{1}{2x^4}+\&c.\right\}}{1-\left\{1+\frac{x_1 x_2 x_3 x}{2}\right\}\left\{1-\frac{1}{2x^4}+\&c.\right\}} \right\}$$

$$= x_1\, x_2\, x_3.$$

Hence (see p. 118, line 5,)

$$\varepsilon_1\int\frac{x^2\,dx}{\sqrt{1+x^4}} + \varepsilon_2\int\frac{x^2\,dx}{\sqrt{1+x^4}} + \varepsilon_3\int\frac{x^2\,dx}{\sqrt{1+x^4}} = \text{constant} + x_1\,x_2\,x_3$$

$$\int\frac{\sqrt{1+x^4}}{x^2}\,dx = -\frac{\sqrt{1+x^4}}{x} + 2\int\frac{x^2\,dx}{\sqrt{1+x^4}},$$

and, since $\frac{\sqrt{1+x^4}}{x} = \frac{1+c_1 x}{x} = \frac{1}{x} + c_1$

$$\varepsilon_1\int_0^{x_1}\frac{\sqrt{1+x^4}}{x^2}\,dx + \varepsilon_2\int_0^{x_2}\frac{\sqrt{1+x^4}}{x^2}\,dx + \varepsilon_3\int_0^{x_3}\frac{\sqrt{1+x^4}}{x^2}\,dx.$$

$$= -\frac{1}{x_1} - \frac{1}{x_2} - \frac{1}{x_3} - \frac{3x_1\,x_2\,x_3}{2} + 2\,x_1\,x_2\,x_3 + \text{constant}$$

$$= -\frac{3}{4}\,x_1\,x_2\,x_3 + \text{constant},$$

which is Mr. Talbot's theorem.

In the numerical examples offered in this paper, I have only carried the approximation as far as could be done conveniently by the common tables of logarithms, that is, to six places of decimals.

If L be the logarithm of the number N, $L+x$ the logarithm of the number $N+y$,

$$N = 1 + p\,L + \frac{p^2}{1\,.\,2}\,L^2 + \frac{p^3}{1\,.\,2\,.\,3}\,L^3 + \text{\&c.}$$

p being the Napierian logarithm of the base.

$$N + y = N\left\{1 + p\,x + \frac{p^2}{1\,.\,2}\,x^2 + \text{\&c.}\right\}$$

$$y = N\,p\,x\left\{1 + \frac{p\,x}{2} + \frac{p^2}{2\,.\,3}\,x^2 + \text{\&c.}\right\}$$

$$\log y = \log\,(N\,p\,x) + \log\left\{1 + \frac{p}{2}\,x + \frac{p^2\,x^2}{2\,.\,3} + \text{\&c.}\right\}$$

$$= \log\,(N\,p\,x) + \frac{x}{2} + \text{\&c.}$$

Also $$x = \frac{1}{p}\left\{\frac{y}{N} = \frac{y^2}{2\,n^2} + \text{\&c.}\right\}$$

$\log p = \cdot 36221\ 56887.$

With the help of these expressions, and the table of Brigg's logarithms to sixty-one places of decimals given in Callet, the approximations may be carried much further if desired.

XX. *Experimental Researches in Electricity.—Eighth Series.* *By* Michael Faraday, *D.C.L. F.R.S. Fullerian Prof. Chem. Royal Institution, Corr. Memb. Royal and Imp. Acadd. of Sciences, Paris, Petersburgh, Florence, Copenhagen, Berlin, &c. &c.*

[Continued from p. 45: with an Engraving.]

915. RETURNING to the consideration of the source of electricity (878, &c.), there is another proof of the most perfect kind that metallic contact has nothing to do with the *production* of electricity in the voltaic circuit, and further, that electricity is only another mode of the exertion of chemical forces. It is, the production of the *electric spark* before any contact of metals is made, and by the exertion of *pure and unmixed chemical forces.* The experiment, which will be described further on (956.), consists in obtaining the spark upon making contact between a plate of zinc and a plate of copper plunged into dilute sulphuric acid. In order to make the arrangement as elementary as possible, mercurial surfaces were dismissed, and the contact made by a copper wire connected with the copper plate, and then brought to touch a clean part of the zinc plate. The electric spark appeared, and it must of necessity have existed and passed *before the zinc and the copper were in contact.*

916. In order to render more distinct the principles which

I have been endeavouring to establish, I will restate them in their simplest form, according to my present belief. The electricity of the voltaic pile (856. note) is not dependent either in its origin or its continuance to the contact of the metals with each other (880. 915.). It is entirely due to chemical action (882.), and is proportionate in its intensity to the intensity of the affinities concerned in its production (908.); and in its quantity to the quantity of matter which has been chemically active during its evolution (869.). This definite production is again one of the strongest proofs that the electricity is of chemical origin.

917. As *volta-electro-generation* is a case of mere chemical action, so *volta-electro-decomposition* is simply a case of the preponderance of one set of chemical affinities more powerful in their nature, over another set which are less powerful; and if the instance of two opposing sets of such forces (891.) be considered, and their mutual relation and dependence borne in mind, there appears no necessity for using, in respect to such cases, any other term than chemical affinity, (though that of electricity may be very convenient,) or supposing any new agent to be concerned in producing the results; for we may consider that the powers at the two places of action are in direct communion and balanced against each other through the medium of the metals (891.), fig. 4, in a manner analogous to that in which mechanical forces are balanced against each other by the intervention of the lever (1031.).

918. All the facts show us that that power commonly called chemical affinity, can be communicated to a distance through the metals and certain forms of carbon; that the electric current is only another form of the forces of chemical affinity; that its power is in proportion to the chemical affinities producing it; that when it is deficient in force it may be helped by calling in chemical aid, the want in the former being made up by an equivalent of the latter; that, in other words, the forces termed chemical affinity and electricity are one and the same.

919. When the circumstances connected with the production of electricity in the ordinary voltaic circuit are examined and compared, it appears that the source of that agent, always meaning the electricity which circulates and completes the current in the voltaic apparatus, and gives that apparatus power and character (947. 996.), exists in the chemical action which takes place directly between the metal and the body with which it combines, and not at all in the subsequent action of the substances so produced with the acid present*. Thus,

* Wollaston, Philosophical Transactions, 1801, p. 427, [or Phil. Mag., vol. xi., p. 206.—Edit.]

when zinc, platina, and dilute sulphuric acid are used, it is the union of the zinc with the oxygen of the water which determines the current; and though the acid is essential to the removal of the oxide so formed, in order that another portion of zinc may act on another portion of water, it does not, by combination with that oxide, produce any sensible portion of the current of electricity which circulates; for the quantity of electricity is dependent upon the quantity of zinc oxidized, and in definite proportion to it: its intensity is in proportion to the intensity of the chemical affinity of the zinc for the oxygen under the circumstances, and is scarcely, if at all, affected by the use of either strong or weak acid (908.).

920. Again, if zinc, platina, and muriatic acid are used, the electricity appears to be dependent upon the affinity of the zinc for the chlorine, and to be circulated in exact proportion to the number of particles of zinc and chlorine which unite, being in fact an equivalent to them.

921. But in considering this oxidation, or other direct action upon the METAL itself, as the cause and source of the electric current, it is of the utmost importance to observe that the oxygen or other body must be in a peculiar condition, namely, in the state of *combination*; and not only so, but limited still further, to such a state of combination, and in such proportions as will constitute an *electrolyte* (823.). A pair of zinc and platina plates cannot be so arranged in oxygen gas as to produce a current of electricity, or act as a voltaic circle, even though the temperature may be raised so highly as to cause oxidation of the zinc far more rapidly than if the pair of plates were plunged into dilute sulphuric acid, for the oxygen is not part of an electrolyte, and cannot therefore conduct the forces onwards by decomposition, or even as metals do by itself. Or if its gaseous state embarrass the minds of some, then liquid chlorine may be taken. It does not excite a current of electricity through the two plates by combining with the zinc, for its particles cannot transfer the electricity active at the point of combination, across to the platina. It is not a conductor of itself, like the metals; nor is it an electrolyte, so as to be capable of conduction during decomposition, and hence there is simple chemical action at the spot, and no electric current *.

* I do not mean to affirm that no traces of electricity ever appear in such cases. What I mean is that no electricity is evolved in any way, due or related to the causes which excite voltaic electricity, or proportionate to them. That which does appear occasionally is the smallest possible fraction of that which the acting matter could produce if arranged so as to act voltaically, probably not the one hundred thousandth, or even the millionth part, and is very probably altogether different in its source.

922. It might at first be supposed that a conducting body, not electrolytic, might answer as the third substance between the zinc and the platina; and it is true that we have some such capable of exerting chemical action upon the metals. They must, however, be chosen from the metals themselves, for there are no bodies of this kind except those substances and charcoal. To decide the matter by experiment, I made the following arrangement. Melted tin was put into a glass tube bent into the form of the letter V, fig. 6, (Plate I.) so as to fill the half of each limb, and two pieces of thick platina wire, *p*, *w*, inserted, so as to have their ends immersed some depth in the tin; the whole was then allowed to cool, and the ends *p* and *w* connected with a delicate galvanometer. The part of the tube at *x* was now reheated, whilst the portion *y* was retained cool. The galvanometer was immediately influenced by the thermo-electric current produced. The heat was steadily increased at *x*, until at last the tin and platina combined there; an effect which is known to take place with strong chemical action and high ignition; but not the slightest additional effect occurred at the galvanometer. No other deflection than that due to the thermo-electric current was observable the whole time. Hence, though a conductor, and one capable of exerting chemical action on the tin, was used, yet, not being an *electrolyte*, not the slightest effect of an electrical current could be observed (947.).

923. From this it seems apparent that the peculiar character and condition of an electrolyte is *essential* in one part of the voltaic circuit; and its nature being considered, good reasons appear why it and it alone should be effectual. An electrolyte is always a compound body; it can conduct, but only whilst decomposing. Its conduction depends upon its decomposition and the *transmission of its particles* in directions parallel to the current; and so intimate is this connexion, that if their transition be stopped, the current is stopped also; if their course be changed, its course and direction changes with them; if they proceed in one direction, it has no power to proceed in any other than a direction invariably dependent on them. The particles of an electrolytic body are all so mutually connected, are in such relation with each other through their whole extent in the direction of the current, that if the last is not disposed of, the first is not at liberty to take up its place in the new combination which the powerful affinity of the most active metal tends to produce; and then the current itself is stopped; for the dependencies of the current and the decomposition are so mutual, that whichever be originally determined, *i. e.* the motion of the particles or the motion of the

current, the other is invariable in its concomitant production and its relation to it.

924. Consider, then, water as an electrolyte and also as an oxidizing body. The attraction of the zinc for the oxygen is greater under the circumstances, than that of the oxygen for the hydrogen; but in combining with it, it tends to throw into circulation a current of electricity in a certain direction. This direction is consistent (as is found by innumerable experiments) with the transfer of the hydrogen from the zinc towards the platina, and the transfer in the opposite direction of fresh oxygen from the platina towards the zinc; so that the current *can pass* in that one line, and, whilst it passes, can consist with and favour the renewal of the conditions upon the surface of the zinc, which at first determined both the combination and [the] circulation. Hence the continuance of the action there, and the continuation of the current. It therefore appears quite as essential that there should be an electrolyte in the circuit, in order that the action may be transferred forward, in a *certain constant direction*, as that there should be an oxidizing or other body capable of acting directly on the metal; and it also appears to be essential that these two should merge into one, or that the principle directly active on the metal by chemical action should be one of the *ions* of the electrolyte used. Whether the voltaic arrangement be excited by solution of acids, or alkalies, or sulphurets, or by fused substances (476.), this principle has always hitherto, as far as I am aware, been an *anion* (943.); and I anticipate, from a consideration of the principles of electric action, that it must of necessity be one of that class of bodies.

925. If the action of the sulphuric acid used in the voltaic circuit be considered, it will be found incompetent to produce any sensible portion of the electricity of the current by its combination with the oxide formed, for this simple reason, it is deficient in a most essential condition; it forms no part of an electrolyte, nor is it in relation with any other body present in the solution which will permit of the mutual transfer of the particles and the consequent transfer of the electricity. It is true, that as the plane at which the acid is dissolving the oxide of zinc formed by the action of the water, is in contact with the metal zinc, there seems no difficulty in considering how the oxide there could communicate an electrical state, proportionate to its own chemical action on the acid, to the metal, which is a conductor without decomposition. But on the side of the acid there is no substance to complete the circuit: the water, as water, cannot conduct it, or at least only so small a proportion that it is merely an incidental and al-

most inappreciable effect (970.); and it cannot conduct it as an electrolyte, because an electrolyte conducts in consequence of the *mutual* relation and action of its particles; and neither of the elements of the water, nor even the water itself, as far as we can perceive, are *ions* with respect to the sulphuric acid (848.)*.

926. This view of the secondary character of the sulphuric acid as an agent in the production of the voltaic current, is further confirmed by the fact, that the current generated and transmitted is directly and exactly proportional to the quantity of water decomposed and the quantity of zinc oxidized (868. 991.): and is the same as that required to decompose the same quantity of water. As, therefore, the decomposition of the water shows that the electricity has passed by its means, there remains no other electricity to be accounted for or to be referred to any action other than that of the zinc and the water on each other.

927. The general case (for it includes the former one (924.),) of acids and bases, may theoretically be stated in the following manner. Let *a*, fig. 7. be supposed to be a dry oxyacid, and *b* a dry base, in contact at *c*, and in electric communication at their extremities by plates of platina *p p*, and a platina wire *w*. If this acid and base were fluid, and combination took place at *c*, with an affinity ever so vigorous, and capable of originating an electric current, the current could not circulate in any serious degree; because, according to the experimental results, neither *a* nor *b* could conduct without being decomposed, for they are either electrolytes or else insulators, under all circumstances, except to very feeble and unimportant currents (970. 986.). Now the affinities at *c* are not such as tend to cause the *elements* either of *a* or *b* to separate, but only such as would make the two bodies combine together as a whole; the point of action is, therefore, insulated, the action itself local (921. 947.), and no current can be formed.

928. If the acid and base be dissolved in water, then it is possible that a small portion of the electricity due to chemical action may be conducted by the water without decomposition (966. 984.); but the quantity will be so small as to be utterly disproportionate to that due to the equivalents of chemical force; will be merely incidental; and, as it does not involve

* It will be seen that I here agree with Sir Humphry Davy, who has experimentally supported the opinion that acids and alkalies in combining do not produce any current of electricity. Philosophical Transactions 1826, p. 398. [or Phil. Mag. and Annals, N.S. vol. i. p. 98.—Edit.]

the essential principles of the voltaic pile, it forms no part of the phænomena at present under investigation*.

929. If for the oxyacid a hydracid be substituted (927.), —as one analogous to the muriatic, for instance,—then the state of things changes altogether, and a current due to the chemical action of the acid on the base is possible. But now both the bodies act as electrolytes, for it is only one principle of each which combine mutually,—-as, for instance, the chlorine with the metal,—and the hydrogen of the acid and the oxygen of the base are ready to traverse with the chlorine of the acid and the metal of the base in conformity with the current and according to the general principles already so fully laid down.

930. This view of the oxidation of the metal, or other *direct* chemical action upon it, being the sole cause of the production of the electric current in the ordinary voltaic pile, is supported by the effects which take place when alkaline or sulphuretted solutions (931. 943.) are used for the electrolytic conductor instead of dilute sulphuric acid. It was in elucidation of this point that the experiments without metallic contact, and with solution of alkali as the exciting fluid, already referred to (884.), were made.

931. Advantage was then taken of the more favourable condition offered, when metallic contact is allowed (895.), and the experiments upon the decomposition of bodies by a single pair of plates (899.) were repeated, solution of caustic potassa being employed in the vessel *v*, fig. 5. in place of dilute sulphuric acid. All the effects occurred as before: the galvanometer was deflected; the decompositions of the solutions of iodide of potassium, nitrate of silver, muriatic acid, and sulphate of soda ensued at *x*; and the places where the evolved principles appeared, as well as the deflection of the galvanometer, indicated a current in the *same direction* as when acid was in the vessel *v*; i. e. from the zinc through the solution to the platina, and back by the galvanometer and decomposing agent to the zinc.

932. The similarity in the action of either dilute sulphuric acid or potassa goes indeed far beyond this, even to the proof of identity in *quantity* as well as in *direction* of the electricity produced. If a plate of amalgamated zinc be put into a solution of potassa, it is not sensibly acted upon; but if touched

* It will, I trust, be fully understood, that in these investigations I am not professing to take an account of every small, incidental, or barely possible effect, dependent upon slight disturbances of the electric fluid during chemical action, but am seeking to distinguish and identify those actions on which the power of the voltaic battery essentially depends.

in the solution by a plate of platina, hydrogen is evolved on the surface of the latter metal, and the zinc is oxidized exactly as when immersed in dilute sulphuric acid (863.). I accordingly repeated the experiment before described with weighed plates of zinc (864. &c.), using however solution of potassa instead of dilute sulphuric acid. Although the time required was much longer than when acid was used, amounting to three hours for the oxidizement of 7·55 grains of zinc, still I found that the hydrogen evolved at the platina plate was the equivalent of the metal oxidized at the surface of the zinc. Hence the whole of the reasoning which was applicable in the former instance applies also here, the current being in the same direction, and its decomposing effect in the same degree, as if acid instead of alkali had been used (868.).

933. The proof, therefore, appears to me complete, that the combination of the acid with the oxide, in the former experiment, had nothing to do with the production of the electric current; for the same current is here produced when the action of the acid is absent, and the reverse action of an alkali is present. I think it cannot be supposed for a moment, that the alkali acted chemically as an acid to the oxide formed; on the contrary, our general chemical knowledge leads to the conclusion, that the ordinary metallic oxides act rather as acids to the alkalies: yet that kind of action would tend to give a reverse current in the present case, if any were due to the union of the oxide of the exciting metal with the body which combines with it. But instead of any variation of this sort, the direction of the electricity was constant, and its quantity also directly proportional to the water decomposed, or the zinc oxidized. There are reasons for believing that acids and alkalies, when in contact with metals upon which they cannot act directly, still have a power of influencing their attractions for oxygen (941.); but all the effects in these experiments prove, I think, that it is the oxidation of the metal necessarily dependent upon, and associated as it is with, the electrolyzation of the water (921. 923.), that produces the current; and that the acid or alkali merely act as solvents, and by removing the oxidized zinc, allow other portions to decompose fresh water, and so continue the evolution or determination of the current.

934. The experiments were then varied by using solution of ammonia instead of solution of potassa; and as it, when pure, is a bad conductor, like water (554.), it was occasionally improved in that power by adding sulphate of ammonia to it. But in all the cases the effects were the same as before; decompositions of the same kind were effected, and the electric

current producing these was in the same direction as in the experiments just described.

[To be continued.]

XXI. *Notice of the Optical Properties of a new Mineral supposed to be a Variety of Cymophane. By* Sir DAVID BREWSTER, K.H., F.R.S.

HAVING just received from my friend Mr. Nils Nordenskiold of Helsingfors, a specimen of a new mineral having interesting optical properties, I hasten to communicate a brief notice of these to the readers of this Journal.

Mr. Nordenskiold received specimens of this mineral last spring from His Excellency Sir L. Peroffsky of St. Petersburgh. It was found in the Emerald mines near Caterinenburg in Siberia; and it occurs in large crystals from one to two inches in diameter, which are generally composed in the same manner as is shown in fig. 38, plate vii., of the second volume of Mohs's Mineralogy. Mr. Hartwall is at present engaged in analysing the mineral, the result of which we shall communicate as soon as it reaches us. Mr. Nordenskiold, however, has ascertained that its colouring matter depends on a small admixture of *oxide of chromium*.

When this mineral is seen in daylight it is of a bright *green* colour, whereas by candlelight its colour is a *pink red.* Mr. Nordenskiold has likewise observed, that when a compound crystal is examined with a piece of tourmaline, or in polarized light, one portion of it is of an *emerald green* colour, while another is of a *faint dirty yellow* colour; and that when the crystal is turned round 60°, the part which was *yellow* becomes *emerald green*, and *vice versâ.* Mr. Nordenskiold adds that the mineral seems to be more transparent in candle- than in daylight.

Having repeated these experiments I have found them in every respect perfectly correct; the *yellow* colour, however, which is described as dirty, loses this character when the specimen is placed in a fluid, and it then appears to be intermixed with *red*, so as to show that if the thickness of the specimen were successively increased, the colour would be *redder* and *redder*, and terminate in a *bright red* tint.

Although Mr. Nordenskiold has mentioned that the compound crystals resemble the starlike compound crystals of *carbonate of lead* figured by Mr. Haidinger in his edition of Mohs's Mineralogy, yet, from the optical phænomena, we are disposed to regard the compound as consisting of three single crystals united at angles of 60°, for if the united crystals were each compound, the colours would change at every 30° of revolution.

The change of colour which is exhibited by looking through the mineral in *day*- and in *candle*-light, arises from two causes: 1st, from there being an *excess* of *red* and a *defect* of *blue* rays in the light of a candle compared with the light of day; and 2ndly, from the substance employed having a greater disposition to transmit one kind of rays in preference to another, or, what is the same thing, being more transparent for one kind of rays than for another kind, when their intensity is the same.

In the present mineral its colour is *green*; but when we analyse it with the prism we find that the *green* is a compound colour consisting of red and green, the *green* predominating greatly in *day*light: but in *candle*light the colour is a *pink red*, because the *greater* quantity of *red* in this light and the *smaller* quantity of blue and *green*, gives the *red* colour a decided predominance over the *green*, so as to make the compound colour *pink red*.

There are several crystals, natural and artificial, and various solutions in which this change of colour is beautifully seen. It is particularly visible in the *green* juices of plants, which are *green* in daylight, and of a *blood red* colour in the light of a candle.

In the mineral under our consideration Mr. Nordenskiold found traces of the *oxide of chromium*, to which he attributes its colour. That this is the colouring matter, and that the action of this metal is the cause of its peculiar property in reference to light, may be inferred from the fact that the very same property is possessed by the *triple oxalate of chromium and potash*, and also by the *sulphate* of *ammonia and chromium*, whether these salts are used in the solid state or in a state of solution.

XXII. *On the Refraction and Polarization of Heat.* By James D. Forbes, *Esq., F.R.SS. L. & E., Professor of Natural Philosophy in the University of Edinburgh.**

§ 1. *Some Miscellaneous Experiments with the Thermo-Multiplier.* § 2. *On the Polarization of Heat by Tourmaline.* § 3. *On the Polarization of Heat by Refraction and Reflection.* § 4. *On the Depolarization and Double Refraction of Heat.*

1. THE experiments to be detailed in this paper, which chiefly go to establish properties of heat wholly unlooked for, or only suspected to exist, having been made en-

* Communicated by the Author; having been read before the Royal Society of Edinburgh on the 5th and 19th of January 1835.

tirely by means of an instrument of great delicacy—the thermo-multiplier of MM. Nobili and Melloni,—I shall premise some account of its application to the investigation of some more familiar modes of action.

§ 1. *Miscellaneous Experiments.*

2. We could hardly quote a stronger proof of the rapid and unexpected advances which enlarged theory may produce in practice, than by referring to the employment of thermo-electric action, discovered a few years since by Seebeck, to the measurement of heat, with a degree of accuracy and facility which, perhaps, no thermometer has ever attained. Such is the principle of the thermo-multiplier of Nobili and Melloni. It is well known, that when two metals (and especially bismuth and antimony) are soldered together, and the point of union heated, an electric current is established from the one metal to the other, which may be carried off by wires, and caused to act upon a delicate galvanometer or multiplier, the needle of which serves as an index; the galvanometer consisting, of course, of a magnetic needle, nearly freed from the influence of the earth's magnetism, and so connected with the wire which transmits the electricity, that the mutual influence of the magnetism and the electricity shall (by the law of Œrsted) be a maximum.

3. It will readily be conceived, that, if a series of alternating bars of bismuth and antimony be placed parallel to each other, and the extremities alternately soldered together, when all the extremities facing one way are heated (as by the radiant influence of a lamp), whilst the others remain at the temperature of the apartment, the effects produced in a single pair, such as we first supposed, will be produced at each junction, and that the intensity of the whole effect will be greater, just as in the voltaic pile. At one time it appeared doubtful how far electricity, of such small tension as is thus produced, could be so reinforced; but the instrument in question seems to prove the practicability of it. About thirty pairs are employed, and so delicately are they made, that the ends which exhibit one set of junctions are contained within a superficial area of four tenths of an inch square.

4. The wires, from the extremity of the first and last element (just as in the voltaic battery), convey the electricity to the multiplier, which consists of a flattened coil of silver-wire, covered with silk, the coils of the wire being parallel to the quiescent position of an astatic magnetic needle, which is perpendicular to the magnetic meridian. The deviations are measured in the usual manner, on a divided circle; upon

which, with practice, ¼th of a degree may always be observed, and even minuter quantities occasionally estimated. These divisions are not necessarily proportional to the intensities of the currents which produce the corresponding deviations. The coils of wire, extending a long way on each side of zero, prevent the effect from diminishing so rapidly as if they were concentrated there; and M. Melloni has described, in his paper in the *Annales de Chimie* for May 1833, a simple and satisfactory method of estimating the relative values of degrees, at different points of the scale. He states, however, that, under 20° of deviation, he found them quite uniform. In the following experiments, the deviations were generally under 15°, and in almost no case exceeded 20°. I have therefore assumed the forces to be as the deviations. Besides, no change of importance would take place from a deviation from this law by a small quantity.

5. It will be perceived in the experiments which are to be detailed, that the determination of all the more important facts depend generally on whether one effect be greater or less than another, without much regard to their absolute amount. Now, the confidence which we can place in the uniformity of this instrument, or at least of the small changes capable of affecting it (since it is not liable like thermometers, and especially air-thermometers, to advance by starts,) is such, as to admit of almost indefinite subdivision, where the relations of small quantities are alone concerned. I conceived, therefore, that without impairing its sensibility by lengthening the galvanometer needle, we might advantageously magnify the divisions by optical means. This I proposed to do by observing the motions of the index by means of a small telescope, fixing in front of the object glass a lens whose focus is situated at the part of the scale desired to be magnified. It might also be easy, in order to compare larger quantities, to make this micrometrical system revolve so as to be always similarly placed as regards the needle, and thus avoid the effects of parallax, which at present require constant vigilance.

6. The method here indicated, I have put into practice with the greatest success in my later researches; one tenth of a degree becomes easily visible, and the constancy of the indications fully justifies this method of microscopic examination, which has enabled me to verify the most delicate deductions I had drawn from simple observation, and to obtain results which otherwise I must have been unable confidently to announce.

7. For the precautions to be employed in the use of the thermo-multiplier, I must refer to the first of M. Melloni's very original papers in the *Annales de Chimie* (for May 1833),

but I may state, once for all, that when once habituated to the use of it, I have found it more simple, manageable, and comparable, than I could previously have imagined. Notwithstanding its delicacy and the promptitude of its action, a few precautions suffice to prevent any derangement from without. The only inconvenience which I experienced, was in the determination of the zero of the scale, which appears liable to some fluctuations, which may be considered as accidental. It rarely happened, however, that these affected the results of my experiments, because, as I have said, these were always confined to small variations of temperature (indicated by a deviation generally under 15° on the scale) when such fluctuations did not appear; and the results produced by the same cause under the same circumstances were admirably constant, as well as the position of the zero point.

8. There is one circumstance which gives a degree of delicacy to the indications of the thermo-multiplier, when we wish to ascertain very minute differences of effect, which no other thermometric instrument possesses. When we wish to ascertain the *existence*, not the *measure*, of some cause of heat or cold, if we watch the needle of the multiplier at the instant at which the change of circumstances intended to produce the effect takes place, we shall perceive, in the instantaneous effect on the needle, an evidence of a far more decisive character than the *merely statical* deviation (at which, after several oscillations, it is finally to settle) could afford. Not only does the acquired velocity carry it through double the space due to the statical effect; but I have observed that the action of the thermo-electric pile so far resembles that of the voltaic, that we appear to have an excess of effect at the first moment of action, which gives a greater deviation than can be afterwards obtained*. It is therefore to be recollected, that, in speaking confidently of effects, which, statically speaking, are exceedingly small, the experimentalist has a species of evidence far stronger than the mere numerical expression of the deviation of the needle, but the degree of which must be taken on the

* This remarkable effect, which may be described as an increase of tension by confinement, seems generally to exist where the conductors of imponderable agents oppose considerable resistance to their passage. It is familiar in voltaic electricity, and I have often observed it in magnetic electricity. It is similar to the action which I have attempted to demonstrate in the passage of heat from good to bad conductors (see Lond. and Edinb. Phil. Mag., vol. iv., p. 15, *et seq.*), where we have the full advantage of the dynamical effect; whilst the existence of statical tension in heat seems likewise to be proved (as we might have anticipated) by the beautiful experiment described by Professor Powell in the Philosophical Transactions for 1834, and noticed in the last number of this Journal, p. 58.

faith of his veracity. Thus I have obtained repeated differences, not exceeding half or even *a quarter of a degree* of the multiplier (observed without a telescope), which, by the promptitude with which the needle was repelled or attracted at the instant that the change of circumstances to be considered was effected, left as little doubt in my mind as if the numerical result had been many times greater.

9. Having satisfied myself, in a variety of ways, of the extreme delicacy and promptitude of action of this instrument, I thought of applying it to detect the heat of the moon's rays in a more unexceptionable manner than, I am persuaded, it has ever been attempted. This curious question had not escaped MM. Nobili and Melloni when they first constructed the instrument, and they mention in their first account of the thermo-multiplier their attempts at its solution*. But, like previous experimenters, they employed a metallic mirror to concentrate the rays of the moon, which, acting in the usual manner of dispersing the heat of the thermometer, produced so great a cooling effect, as completely to neutralize any positive results.

10. It occurred to me, however, from the consideration of M. Melloni's very decisive experiments as to the permeability of screens of different kinds to heat from various sources, that the moon's heat must, in very great proportion at least, radiate through glass. And this on several grounds; as, 1. because the sun's heat, of which this may be considered as an integral part, does so with scarcely any loss; 2. because heat, accompanied by light, *always* does so, and generally in proportion to the brilliancy and refrangibility of that light; and, 3. because the lunar rays having passed through the whole thickness of the atmosphere must, according to the experiments of De la Roche, fully confirmed by Melloni, have parted with the greater part of that species of heat most easily stopped, and hence arrive at the earth in a state comparatively capable of passing through glass and similar substances. If this opinion be correct (nor can I entertain any doubt upon it), if we substitute a lens for a mirror to concentrate the lunar rays, we shall profit by all, or nearly all, of their heating effect, whilst such a lens, instead of promoting the radiation of the heat of the thermometer to the sky, will *entirely stop it* (because heat of this description does not pass sensibly through the thinnest glass), and thus its disturbing influence will be entirely prevented.

11. I employed, therefore, a polyzonal lens made by Soleil of Paris, in my custody, to concentrate the moon's light. The diameter of the lens is 30 inches; its focal distance about 41

* *Annales de Chimie et de Physique*, December 1831.

inches, whence we may compute the size of the lunar image to be a circle 0·38 inch in diameter. Comparing this with the dimensions of the intercepted cylinder of rays, we shall find the concentration to exceed 6000 times. But even if we admit that half the rays are reflected, dispersed and absorbed, we shall have still an effective increase of 3000 times.

12. My experiments were made on the 16th December 1834, between 9 and 11 o'clock, the moon being only 18 hours past full, and (towards the close) less than 2 hours from the meridian. She was also particularly high, having a declination of 25° north. The thermal pile, which was particularly commodious for the experiment, had one extremity elevated to the proper angle, and being placed accurately in the focus of the mirror, the moon's image was brilliantly thrown on the extremity of the pile. The sky was on the whole very pure, though an occasional milkiness was perceived, but the best observations were made at the clearest moments, because then the air was also most still; for though the instrument was placed in a most sheltered spot, the faintest breeze was indicated by a deflection of the needle, and with such promptitude, that I generally could perceive in this way its approach before I could feel it. The action of the lens was so perfect, that the image was perfectly sharp, and the spots clearly defined. The lunar rays were alternately screened and admitted by an assistant passing a sheet of pasteboard across the surface of the lens *next the moon*; for when it was interposed between the lens and the instrument, a sensible disturbance took place. By these and other precautions, the needle was steady beyond my expectations, and during an hour and a quarter that the observation lasted, I had probably at least twenty perfectly unexceptionable comparative observations, free from the influence of wind, and which invariably gave not the faintest indication of warmth. When I got a deviation of the needle at the moment of unscreening the moon's rays, I verified it by screening them instantly, and watching for a return to zero, but I was always disappointed. I feel quite confident that the effect, if there was any, could not amount to *a quarter of a degree* of the galvanometer; and, owing to the *dynamical* effect which I have described of a first impulse, that it is improbable that it amounted to half that quantity.

13. Hence it becomes an object of interest to form some estimate of the sensibility of the thermo-multiplier, compared to common thermometers. It would be difficult to give a precise measure of the degrees of temperature of the two extremities of the pile*, but we may compare the effect of equal

* This might best be done by adapting a differential thermometer of extreme delicacy, so that the balls might be in contact with the two extre-

quantities of heat upon this and another instrument. For this purpose I employed two air thermometers of great delicacy; one was the photometer of Leslie, having one ball covered with lamp black, and exposed to the same source of heat as the pile, whilst the other ball was shaded. The other instrument was a vertical differential thermometer, having a hemispherical reflector, intercepting a cone of rays 2·50 square inches in section. I found it impossible to operate with small degrees of heat, which could not be reckoned accurately on the air thermometers, owing to their tardy action; but, from several experiments, I concluded that the same quantity of heat falling on the photometer ball and on the pile, moved the liquid of the former through 1°, and the needle of the multiplier through 4°·2. The degrees of the photometer being 10ths of 1° cent., one centigrade degree would correspond to 42° of the galvanometer (assumed of equal value throughout the scale). The experiment with the differential thermometer, being similarly conducted, gave for the effects of equal quantities of heat, 1° cent. to 62° of the multiplier. If we assume from these experiments that a quantity of heat which raises an air thermometer by one fiftieth of a centigrade degree, affects the galvanometer by 1°, since *a quarter* of a degree of the latter is a *measurable* quantity, and half of that may be estimated as a sensible impression, we may measure an effect of $\frac{1}{200}$ of a centigrade degree, and perceive (by unassisted vision), an effect of $\frac{1}{400}$.

14. In the case of the moon's rays, concentrated 3000 times, we have seen that it is improbable that even the last effect was produced. The whole sensitive extremity of the pile being larger than the moon's image, was not brought into action; but if we compare their relative dimensions*, we shall still find that it is improbable that the direct light of the moon would raise a thermometer *one three-hundred-thousandth part of a centigrade degree*, at least in this climate.

15. The value of the thermo-multiplier consists not so much in the minuteness of its indications, which may easily be equalled by employing large enough thermometers, but in the certainty and rapidity of its action. Air thermometers, such as I compared it with, though the size of the balls was inconsiderable, required so long a time to assume their temperature,

mities of the pile, and the spaces round them filled up with copper filings, or some such material. But the experiment could hardly be quite decisive.

* The moon's image contained 0·114 square inches, whilst the area of the pile is about 0·40. Hence little more than a fourth of the pile was brought fully into action; but any dispersed light (for which we have made allowance), would act on the neighbouring parts.

that, when exposed simultaneously with the thermal pile to the source of heat, the latter had almost assumed its maximum effect before the others had sensibly moved; and it is obvious that, in delicate experiments, where constancy in the producing cause is presumed, rapidity of execution is essential. In short, with an air thermometer (which requires from 10 to 15 minutes to give a single result), the greater part of the experiments to be described would have been impossible from this cause alone, and the remainder would have been tedious beyond measure. It will therefore be conceived that were thermometers enlarged so as to give as minute indications as the multiplier, they would be utterly unmanageable.

16. Of all the researches of M. Melloni on radiant heat that of the refrangibility of non-luminous heat by a prism of rock salt is the most striking. Viewing it in connexion with the theory of heat, and its analogies with light, this experiment is even more important than those connected with the very obscure subject of absorption, which has been illustrated by his numerous determinations of the stoppage of radiant heat, by screens or media of different kinds. At the time when I commenced these experiments, in November last, I was not aware that M. Melloni had published a *second* memoir, which, after many of my experiments were made, I met with in the fifty-fifth volume of the *Annales de Chimie*. It appeared to me a matter of great interest to determine the refrangibility of non-luminous heat by direct experiment; and, in doing this, I was led to verify, in the fullest manner, the published experiments of M. Melloni on the refraction of heat, not merely derived from brass heated by an alcohol lamp, so as not to have the faintest luminosity in the dark, but also of heat derived simply from water under its boiling point. I found that so admirable was the sensibility of the instrument, that we may determine, with great accuracy, by repeated trials, the angular position of the prism which gives the maximum effect; and, having given the angles made by the incident and emergent rays with the sides of the prism under those circumstances, we may compute the index of refraction for the rock-salt, in regard to rays of heat. Upon making the calculation, it appeared that the direction thus experimentally found, gave nearly the same result as for light, which was an ample proof of the reality and striking nature of the experimental result; but it at the same time appeared that the whole dispersion for the spectrum is so inconsiderable, that, in this way, we could hardly expect to obtain a numerical result for the dispersion of the heating rays. I afterwards found, upon reading M. Melloni's second memoir, that he had experienced the same difficulties, and that, though he constructed a pile on purpose,

he had not succeeded in obtaining numerical results. He found, however, that the refrangibility of the rays diminished with their temperature. I also obtained a slight refraction of non-luminous heat through a glass prism.

17. But if heat be capable of refraction by the ordinary agents, an important question arises, Is the phænomenon of double refraction common to heat and light? Rock-salt, the only substance yet discovered which transmits dark heat in large quantity, does not possess this power. To attempt it with Iceland spar would certainly be fruitless, from the very small transmitting power which it possesses, besides some other practical difficulties which suggest themselves. It must be by more refined processes that we can detect this property. Such will be stated in the sequel.

[To be continued.]

XXIII. *Proceedings of Learned Societies.*

ROYAL SOCIETY.

1834. Nov. 20.—A PAPER was read, entitled, "On the Determination of the Terms in the disturbing Function of the fourth Order, as regards the Eccentricities and Inclinations which give rise to secular inequalities." By J. W. Lubbock, Esq., V.P. and Treas. R.S.

The author observes, that the magnitude of the terms of the fourth order in the disturbing function, relating to the inclinations, in the theory of the secular inequalities of the planets, does not admit of being estimated *à priori*; and consequently the amount of error which may arise from neglecting them cannot be appreciated. The object of the present investigation is to ascertain the analytical expressions of these terms; and the method adopted for this purpose is derived from principles already explained by the author in a former paper. He has bestowed great pains in putting these expressions into the simplest form of which they are susceptible; and has finally succeeded, after much labour of reduction, in obtaining expressions of remarkable simplicity. He exemplifies their application by the calculation, on this method, of one of the terms given by Professor Airy as requisite for the determination of the inequality of Venus; and arrives, by this shorter process, at the same result. The same method, he remarks, is, with certain modifications, applicable to the development of the disturbing function in terms of the true longitude.

A paper was also read, entitled "Note on the Astronomical Refractions." By James Ivory, Esq., K.H., M.A., F.R.S.

The object of this communication is to show how far the author has been successful in establishing the true theory of astronomical refractions, in his paper published in the Philosophical Transactions for 1823, by comparing the results of that theory with the best and most recent observations; namely, those recorded in the "Funda-

menta Astronomiæ" of Bessel, and the "Tabulæ Regiomontanæ" of the same author. This comparison is made by taking the first and second differences of the series of the logarithms of the refractions in each table; from which it results that these differences, derived from the numbers in Bessel's tables, are very irregular; but that their mean very nearly coincides with that of the numbers given in the tables of the author.

November 27.—A paper was read, entitled, "Meteorological Journal kept at the Royal Observatory, Cape of Good Hope, from the 1st of February to the 31st of May, 1834." By Thomas Maclear, Esq. Communicated by Captain Beaufort, R.N., F.R.S.

The tables of meteorological observations which compose nearly the whole of this paper are preceded by a short notice of the instruments, namely, one barometer and two thermometers, with which the observations were made. The author announces his intention to forward, in a future communication, the results of a comparison between his barometer and that of Sir John Herschel. The observations are taken at sunrise, at noon, at sunset, and at midnight.

The reading of a paper was commenced, entitled, "On the Proofs of a gradual Rising of the Land in certain parts of Sweden." By Charles Lyell, Esq., F.R.S.

At the Anniversary Meeting, December 1, 1834, which was held on that day in consequence of St. Andrew's Day falling on a Sunday, John William Lubbock, Esq., M.A., V.P. and Treasurer, in the Chair, the Treasurer stated that he took the Chair on the present occasion in consequence of the unavoidable absence of His Royal Highness the President; from whom he had received the following letter:

"Dear Sir,

"May I request of you to express to the gentlemen assembled this day at the Royal Society Rooms, my extreme regret that the state of my eyesight should prevent my attending in my place on the present occasion, as it would otherwise have been both my duty and pleasure to have done? Under these circumstances I must rely upon that kindness which I have ever experienced at their hands since presiding over the interests of the Royal Society, to excuse this involuntary absence on my part. Should the gentlemen kindly vote me again into the Chair, aware as they are of my present infirmities, I can only accept the proffered honour upon an understanding that should I not be better at this period next year, I may be now considered as giving them notice that I shall consider myself bound in duty to resign an office, the duty of which I am no longer able to perform. I regret much being deprived of the pleasure of conferring the medals this day, and particularly the one which has been so properly adjudged to you, for whom I profess the highest consideration, and with which sentiment I subscribe myself,

"Very sincerely, yours, &c.,

(Signed) "AUGUSTUS FREDERICK, P.R.S.

"Kensington Palace, Dec. 1, 1834.

"*John William Lubbock, Esq., Treasurer of the Royal Society.*"

Resolved unanimously,—That this Meeting deeply regrets the afflic-

tion which deprives the Society of His Royal Highness's attendance at the Anniversary Meeting, and confidently hope that his health will be speedily and completely restored.

The Secretary read the following List of Fellows deceased since the last Anniversary.

On the Home List.—Sir Gilbert Blane, Bart., M.D.; John, Marquis of Breadalbane; John Caley, Esq.; Rev. James Stanier Clarke, LL.D.; Captain James Franklin; William Wyndham, Lord Grenville; Philip, Earl of Hardwicke; George Harvey, Esq.; John Jebb, Lord Bishop of Limerick; Rev. Daniel Lysons; William Taylor Money, Esq.; John Sharpe, Esq.; Thomas Snodgrass, Esq.; William Sotheby, Esq.; George John, Earl Spencer; Thomas Telford, Esq.; Right Hon. Charles Philip Yorke.

On the Foreign List.—Don Felipe Bauzà and Professor Karl Ludwig Harding.

The Secretary stated that of these only two, namely, Sir Gilbert Blane and Mr. George Harvey, have contributed papers to the Royal Society.

Sir Gilbert Blane was the author of a paper, entitled, "An Account of the *Nardus Indica*, or Spikenard," which was published in the Philosophical Transactions for 1790.

In this paper, Sir Gilbert, then Dr. Blane, establishes the identity of a species of grass, found in great abundance in a wild unfrequented part of India at the foot of the mountains north of Lucknow, and held in great estimation by the natives as a febrifuge, with the plant denominated by ancient writers the *Nardus Indica*, and which Arrian states was found in great quantity by the armies of Alexander during their marches through the deserts of Gadrosia, bordering on the Persian Gulf, and forming part of the modern province of Mekran. An account of the medicinal properties of this plant occupies the remainder of this paper.

In the year 1788, Sir Gilbert Blane was appointed to read the Croonian Lecture, in which he enters into a general account of the nature of the muscles and of the theory of muscular motion. This paper was not published in the Philosophical Transactions. The portion of it chiefly deserving notice is that which relates to the experiments made by him with a view to determine whether the specific gravity of a muscle is the same in its two states of relaxation and contraction. For this purpose he compared equal portions of the muscular flesh taken from the opposite sides of a fish, one of which had been contracted by crimping, and the other had remained relaxed; but he was unable to detect any sensible difference in their specific gravities. This conclusion was corroborated by the result of experiments on living eels, inclosed in vessels filled with water, and terminating above in a tube of small diameter: the bulk of the fluid was observed to be unaffected by muscular contractions purposely excited in the fish, as appeared from the height of the column in the tube remaining unchanged during the most violent actions of the eels. In caoutchouc, on the other hand, Sir G. Blane found that extension produced a diminution, and retraction an increase, of density.

Mr. George Harvey was the author of a paper entitled "Experimental Inquiries relative to the Distribution and Changes of the Magnetic Intensity in Ships of War;" and of another "On the Effects of the Density of Air on the Rates of Chronometers;" both of which are published in the Philosophical Transactions for 1824. In the first paper he enters into a detail of experiments made on board several vessels for the purpose of determining the influence of the iron in the ships upon the mariner's compass in different situations and under different circumstances. In the second paper he ascertains that the rate of chronometers is accelerated by being placed in air of diminished density; and that it was, on the contrary, retarded when they are subjected to increased atmospheric pressure; the arc of vibration being, in the former case, increased; and in the latter, diminished.

The Secretary then read the Report of the Council, from which the following are extracts; the Report being given entire in the "Proceedings" of the Society.

On the subject of the Library the Council have, in the first place, to report that the manuscript of the classed Catalogue is now very nearly completed, and that the printing of it will be very soon commenced.

The Council beg, in the second place, to congratulate the Society on their having, after so much delay, at length obtained possession of the apartments lately occupied as the Exchequer Office, and granted by the Lords Commissioners of His Majesty's Treasury, on the representation made to them by His Royal Highness our President, to the Royal, conjointly with the Astronomical, Society. The apartments retained by the Royal Society are four in number: the first is a room adjoining to the upper library, from which a door has been opened into it, and which has been fitted up with shelves for the reception of the books formerly kept in the rooms on the basement floor of the next house, under the rooms of the Geological Society. The second is a smaller room, communicating by a door with the Council-room. The third is also a small room, opening into the anteroom, on the same floor. The fourth room is situated on alower floor.

It having been determined at a former Council, in November of last year, that application should be made to the Lords of the Admiralty to direct the observations made at various stations by their order, to be printed at the public expense; Their Lordships have graciously acceded to this request.

The Council, having been applied to by the Commissioners of Excise to undertake the investigation of the proper instruments, and the construction of tables, for ascertaining the strength of spirits, with a view to the more accurate charging of the duty thereon, have appointed a Committee for conducting the proposed inquiry, and fulfilling the objects of the requisition.

The Copley Medal has been awarded by the Council to Professor Plana for his work, entitled "Théorie du Mouvement de la Lune."

The two Royal Medals for the present year have been awarded, the one, on Physics, to John William Lubbock, Esq.; and the other,

on Mineralogy and Geology, to Charles Lyell, Esq. The first is for Mr. Lubbock's highly valuable Investigations on the Tides, contained in his papers published in the Philosophical Transactions.

The second is awarded for Mr. Lyell's work, entitled "Principles of Geology," on the following grounds, the Council at the same time declining to express any opinion on the controverted positions contained in that work.

First, The comprehensive view which the author has taken of the subject, and the philosophical spirit and dignity with which he has treated it.

Secondly, The important service he has rendered to science by specially directing the attention of Geologists to effects produced by existing causes.

Thirdly, His admirable descriptions of many tertiary deposits; several of these descriptions being drawn from original observations.

And lastly, The new mode of investigating tertiary deposits, which his labours have greatly contributed to introduce; namely, that of determining the relative proportions of extinct and still existing species, with a view to discover the relative ages of distant and unconnected tertiary deposits.

The Council, being unable to propose any specific Prize-Question for the Royal Medal in Physics for the year 1837, propose to give one of the Royal Medals for that year to the most important unpublished paper in Physics, communicated to the Royal Society for insertion in their Transactions, after the present date and prior to the month of June 1837.

The Council propose to give the other Royal Medals for the year 1837 to the author of the best paper, to be entitled "Contributions towards a system of Geological Chronology, founded on an examination of fossil remains, and their attendant phænomena."

The following gentlemen were declared duly elected as composing the Council and Officers for the ensuing year; namely,

President: His Royal Highness the Duke of Sussex, K.G.—*Treasurer*: John William Lubbock, Esq., M.A.—*Secretaries*: Peter Mark Roget, M.D.; John George Children, Esq.—*Foreign Secretary*: Charles Konig, Esq.

Other Members of the Council: Charles Frederick Barnwell, Esq.; Henry Thomas De la Beche, Esq.; William Thomas Brande, Esq.; Sir Benjamin Collins Brodie, Bart.; Michael Faraday, Esq.; Henry Holland, M.D.; Rev. Philip Jennings, D.D.; Charles Lyell, jun., Esq.; Herbert Mayo, Esq.; Roderick Impey Murchison, Esq.; Lord Oxmantown; Rev. George Peacock; Rev. Baden Powell; Sir John Rennie; Edward Turner, M.D.; Rev. William Whewell.

GEOLOGICAL SOCIETY.

Dec. 17th.—The reading of a paper "On the physical and geological Structure of the Country to the west of the Dividing Range between Hunter's River (lat. 32° S.) and Moreton Bay (lat. 27° S.), with Observations on the Geology of Moreton Bay and Brisbane River, New South Wales," by Allan Cunningham, Esq., and com-

municated by W. H. Fitton, M.D., F.G.S., begun at the Meeting held on the 3rd of December, was resumed and concluded.

This paper was accompanied by a series of specimens made by the author, who states that he had submitted it to the examination of Dr. Fitton, and that he is indebted to the notes of that gentleman for the geological descriptions embodied in the memoir.

After alluding to the Wingen or Burning Mountain, situated on the south-eastern side of the "dividing range," the author states that the summit of the range, at the point where he crossed it, consists of greenstone slate, and the base of a quartzose conglomerate. Having descended the range, he traversed the low hills which form the eastern side of Liverpool Plains and consist of a similar conglomerate; and afterwards the hills to the north of the Plains composed of a very finely grained granite. Between the latitudes of 31 and 30 degrees the country gradually ascended from the level of Liverpool Plains, or 840 feet, to nearly 2000 feet above the level of the sea, and presented a broken irregular surface, often traversed by low ridges of clay slate. To the north of 30° lat. the exploring party entered a fertile valley, called by Mr. Cunningham Stoddart's Valley. The base of the ridges by which it is bounded, consists of serpentine, and their flanks and summit of hornstone; and the hills at the head of the valley of clay-slate. In the bed of Peel's River, which crosses the northern extremity of the valley, the author noticed a thin horizontal bed of calcareous sandstone, between strata of indurated clay or shale. The country for 50 miles to the north of Peel's River exhibited a moderately undulating surface, covered in some parts with fragments of cellular trap; and the hills which bounded the route on the westward, as far as the parallel of 29° 10′, consisted of a reddish coarse-grained sandstone in nearly horizontal strata. Beyond this point Mr. Cunningham directed his journey to the north-east, and a little to the north of 29° lat. he arrived at Mogo Creek, the banks of which were found to be composed of a coarse friable sandstone. Pursuing the same direction, the country for 40 miles presented a rugged surface, and the prevailing rocks were sandstone and clay slate; but occasionally the tops of the hills formed low terraces composed of a quartzose conglomerate. In the bed of a creek in lat. 28° 26′, and in the meridian of Paramatta, (151° east long.), a hard slaty rock was noticed; and the country beyond it was found to be composed, where it could be examined in the dry water-courses, of flinty slate. In lat. 28° 13′ the party entered upon a fertile district which extended for 18 miles, or to the foot of the Dividing Range in the parallel of 28 degrees. At the base of these mountains Mr. Cunningham procured specimens of basalt containing olivine; at the height of 1877 feet above the level of the sea, the rock consisted of amygdaloid; and the extreme summit, 4100 feet above Moreton Bay, of a brick-red cellular trap, the cells having an elongated form and parallel position.

From this station the author directed his course back towards Hunter's River, but chose a route to the eastward of that by which he had arrived at the foot of the Dividing Range. In a ravine about 20 miles from the extreme point of his journey, and on the confines

of a mountainous region, a reddish granite occurred, and the prevailing formation in the hilly district itself was a gray granite. Leaving this mountainous country and directing his course south-westward, Mr. Cunningham entered upon a less elevated region, composed of clay slate; and in lat. 29° he arrived at a deep gorge similarly constituted, and traversed by a rapid stream, in the bed of which he noticed large boulders of the gray granite. During the next 40 miles the only rocks noticed were reddish granite and fragments of basalt. In lat. 29° 26′ large masses of a fine quartzose conglomerate occurred, and they were afterwards found to be very generally scattered over the adjacent country. The boundary hills of Wilmott Valley are stated to be a fine-grained gray granite; and those which form the head of it, in lat. 30° 11′, of brownish porphyry, containing grains of quartz. The party having crossed these hills subsequently traversed Liverpool Plains and the Dividing Range to Hunter's River, and then returned to the station from which they originally set out.

Mr. Cunningham next offers some remarks on the geology of Moreton Bay and Brisbane River, both of which he visited in 1828 for the purpose of connecting his observations at the foot of the Dividing Range in lat. 28° with the sea coast.

The western shores of Moreton Bay, from the entrance of Pumicestone River to Red Cliff Point, are faced by a reef of considerable breadth, which at low water is stated to exhibit a ledge of chalcedony.

In tracing the Brisbane River, which falls into Moreton Bay, the first rock observed was talc slate or chlorite; and opposite the settlement, 16 miles from the mouth of the river, is a quarry of pinkish claystone porphyry, used for building. In the ravines further up occurs serpentine traversed by veins of asbestos and magnetic iron. Sixty miles from Moreton Bay, ledges of hornstone crop out in the banks; and in the same part of the river a considerable seam of coal appears in its channel. A portion of the stem of a fossil plant, presenting "concentric fibrous bands, and a longitudinal foliated structure at right angles to the bands," was found in the vicinity of the seam of coal. At "the limestone station" on Brenner River, which falls into the Brisbane, Mr. Cunningham procured a series of specimens, which consisted of yellowish hornstone, indurated white marl, resembling some of the harder varieties of chalk, and containing immense masses of black flint, bluish gray chalcedony passing into chert, and a gritty yellowish limestone. A bed of coal has likewise been noticed in the Brenner, and traced from it to the Brisbane. To the south of the limestone station is a remarkable hill, consisting of trap, called Mount Forbes; and 50 miles to the south of the penal settlement on the Brisbane is the Birman range, from which the author procured specimens of compact quartz rock; and from Mount Lindsay, likewise south of the Brisbane, he obtained specimens of granite.

In addition to the collection from the districts already alluded to, Mr. Cunningham has added another, made by Capt. Sturt in an excursion from Bathurst to the marshes of the Macquarie, and hence to the Darling River. It consists of carbonate of copper from a

white argillaceous cliff at Moling Plain; stalactite from the bed of the Macquarie; pink clay from the cataract below Wellington Valley; porphyry from Mount Harris; hard, granular, quartz rock from Oxley's Table Land and Mount Hellvellin; granite from New Year's Creek; a quartzose conglomerate, porphyry, sandstone, white clay, and selenite, from the Darling River; and lastly, specimens of compact limestone, containing coals, from a limestone range 16 miles north from Bathurst.

A paper was next read, entitled "An Account of Land and Freshwater Shells found associated with the Bones of Land Quadrupeds beneath diluvial Gravel, at Cropthorn in Worcestershire," by Hugh Edwin Strickland, Esq., F.G.S.

On two former occasions Mr. Striekland laid before the Society brief notices of the discovery, near Cropthorn, of the bones of extinct quadrupeds associated with shells of existing species, and the present paper contains the result of his continued researches. The deposit in which they were found is situated on the main road from Evesham to Pershore, and on the east side of the small rivulet which flows from Bredon Hill towards the Avon. In May 1834 the deposit presented a section about 70 yards in length and 8 feet 6 inches high in the middle. The lower part of it consisted of lias clay, on which rested a layer of fine sand, containing 23 species of land and freshwater shells, with detached fragments, more or less rolled, of bones of the Hippopotamus, Bos, Cervus, Ursus, and Canis. The sand passes upwards gradually into the gravel, which extends to the surface, and differs in no respect from the other diluvial beds in the neighbourhood. The gravel is composed principally of pebbles of brown quartz, but occasionally contains chalk flints, and fragments of lias Ammonites and Gryphites. The bones, though most abundant in the sand, are interspersed through the gravel; but the shells are entirely confined to the sand. Lists are given of the bones and of the species of the shells, two of which are considered to be extinct. The author from these phænomena assigns the deposit to the newer pliocene era; and from the fluviatile habits of some of the shells, he considers that it occupies the site of an ancient river-bed, and not of a lake. In the course of his paper he points out the inferences which may be drawn from the deposits respecting the greater change which has taken place in the mammifers of this island than in the molluscs, since the era when the gravel was accumulated; and the little change which the climate appears to have undergone since the same epoch. In conclusion he notices the published accounts of similar deposits at North Cliff, near Market Weighton, and at Copford, near Colchester, and his having been informed when at Bath, that freshwater shells had been discovered under gravel in sinking for foundations in the lower part of the city.

A notice was afterwards read, "On the Bones of certain Animals which have been recently discovered in the calcareo-magnesian Conglomerate on Durdham Down, near Bristol," by the Rev. David Williams, F.G.S.

The author commences by observing, that the calcareo-magnesian conglomerate of the neighbourhood of Bristol has hitherto been

singularly deficient in organic remains; and by stating that he is of opinion that their absence may be accounted for by the conglomerate indicating a period of turbulence and agitation. He then alludes to the recent discovery of bones in this deposit on Durdham Down, and to Dr. Riley and Mr. Stuchbury's having determined that they belong to Saurians. These bones, he says, are angular as well as the associated fragments of mountain limestone, and are so intimately incorporated with the latter as to constitute a bone-breccia. He says he has ascertained that the remains belong to at least three animals, varying in their proportions from the Dracæna of Lacèpede to the lesser varieties of Monitors and Safeguards. He afterwards describes a fragment of a small jaw found by himself, which exhibits six distinct alveoli separated by bony partitions. One of the alveoli contains a young tooth, which had cut its way to the summit of the jaw. It is hollow from the base to the apex, and consists of a very thin plate of ivory coated by a thinner sheathing of enamel. The form is triangular, the point keen, the body swells out, and the margin on each side is regularly crenated from the apex downwards. From these characters the author conceives that the animal to which the jaw belonged, may have formed a link between the crocodiles and the lizards proper.

ZOOLOGICAL SOCIETY.

August 26.—An extensive series was exhibited of skins of *Mammalia*, collected in Nepâl by B. H. Hodgson, Esq., Corr. Memb. Z. S., and presented by that gentleman to the Society. It included twenty-two species, several of which were first made known to science by the exertions of Mr. Hodgson, while others still remain to be described by him.

A paper "On the *Mammalia* of Nepâl," written by Mr. Hodgson, has been read before the Asiatic Society of Calcutta, and has been published in the 'Journal' of that Society: but Mr. Hodgson has availed himself of the opportunities which have occurred to him since it was written, to make various additions and corrections in the copy transmitted by him to the Society, portions of which have been read at several previous meetings.

Mr. Hodgson's paper commences by an account of the physical characters of Nepâl, which are so varied, according to the elevation of the several districts, as to render it necessary, when treating on its natural productions, to divide it into three regions. The lower region consists of the Tarâi or marshes, the Bhawar or forest, and the lower hills, and has the climate of the plains of Hindoostan, with some increase of heat and great excess of moisture. The central region includes a clusterous succession of mountains, varying in elevation from 3000 to 10,000 feet, and having a temperature of from 10° to 20° lower than that of the plains. The juxta-Himalayan region, or Kachâr, consists of high mountains, the summits of which are buried for half the year in snow: the climate has nothing tropical about it, except the succession of the seasons.

Mr. Hodgson then enumerates the *Mammalia* which have been observed in Nepâl, adopting in their arrangement the system of Cuvier, and noticing as regards each the region in which it occurs. He adds occasional remarks as to their habits; and notices many which appear to him to be undescribed. An abstract of this portion of his communication is given in the "Proceedings;" from which the following are extracts.

Felis Moormensis, Hodgs., belong to the central region; as does also an undescribed and beautifully marked species.

Felis viverrinus, Benn., is confined to the Tarâi.

Lutra, Linn. Of this genus Mr. Hodgson conceives that no less than seven species are found in Nepâl, five of which differ from the two which inhabit the plains of Hindoostan. Four of these he regards as new, differing materially in length, in bulk and proportions, and in colour; one of them is yellowish white all over; the rest are brown, more or less dark, some having the chin and throat or under surface paled nearly to white or yellow.

Canis familiaris, Linn. The *Pariah* is the only *Dog* of the lower and central regions. The *Thibetan Mastiff* is limited to the Kachâr, into which it was introduced from its native country, but in which it degenerates rapidly; there are several varieties of it.

Canis primævus, Hodgs.

Elephas Indicus, Cuv.,

Rhinoceros unicornis, Cuv., are both abundant in the forest and hills of the lower region, whence in the rainy season they issue into the cultivated parts of the Tarâi to feed upon the rice crops.

Mr. Hodgson suggests that there are two varieties, or perhaps rather species, of the *Indian Elephant*, the Ceylonese and that of the Saul forest. The Ceylonese has a smaller lighter head, which is carried more elevated; it has also higher fore-quarters. The *Elephant* of the Saul forest has sometimes five nails on its hinder feet.

The *Rhinoceros* goes with young from seventeen to eighteen months, and produces one at a birth. At birth it measures 3 feet 4 inches in length, and 2 feet in height. An individual born at Katmandoo eight years since measures now 9 feet 3 inches in length; 4 feet 10 inches in height at the shoulders; the utmost girth of his body is 10 feet 5 inches; the length of the head, 2 feet 4 inches; of the horn, 5 inches: he is evidently far from being adult. It is believed that the animal lives for one hundred years; one, taken mature, was kept at Katmandoo for thirty-five years without exhibiting any symptoms of approaching decline. The young continues to suck for nearly two years. It has when born and for a month afterwards a pink suffusion over the dark colour proper to the mature hide.

Mr. Hodgson states that the wool of the *Huniah* or Bhotean domesticated *Sheep* is superb; and suggests that attempts should be made to naturalize the race in England. To such attempts he is willing to render every assistance in his power. It is suited only for the northern region of Nepâl, suffering much from the heat of the central district.

Specimens were exhibited of several *Reptiles*, which were accompanied by notes by Mr. Gray. These notes were read.

Mr. Gray regards the *Testudo Spengleri*, Walb., as the type of a new genus of *Emydidæ*, having, like the *fresh-water Tortoises* generally, the toes lengthened and covered by a series of shields, but these members, instead of being webbed as in the other genera of the family, are quite free from each other; the legs, moreover, are destitute of fringe along their outer edge. This structure of the feet and limbs indicates habits less aquatic than those of the *Emydidæ* generally; and Mr. Gray states that such appears to be the case with the *Em. Spengleri*, for though he has watched for a considerable time the specimen now living at the Society's Gardens he has never observed it to enter the water.

From the beautiful figure of the animal of *Em. spinosa* given by Mr. Bell in his 'Monograph of the *Testudinata*,' Mr. Gray is inclined to believe that this species belongs to the same genus with *Em. Spengleri*, the toes, especially those of the hind feet, being represented in the figure as quite free. The shells of the two species agree in being of a pale brown colour above, and in being sharply toothed on the margin; in both which respects they differ from the other *fresh-water Tortoises*.

GEOEMYDA.

Testa depressa, ad marginem latè serrata. Pedes utrinque squamis elongatis biseriatis instructi, haud ciliati: digiti liberi, subgraciles, supernè squamis tecti. Caput parvum, cute tenui, lævi, durâ obtectum.

Indiæ (et Africæ?) incolæ.

1. GEOEMYDA SPENGLERI. *Geo. testâ oblongâ, pallidè brunneâ, tricarinatâ, carinis continuis nigro marginatis; margine posticâ profundè serratâ; sterno nigro luteo marginato; scutellis axillaribus inguinalibusque nullis.*

Testudo Spengleri, *Walb., in Berl. Naturf., theil* v. *t.* 3.
Testudo serrata, *Shaw, Gen. Zool., vol.* iii. *t.* 9.
Testudo tricarinata, *Bory St. Vinc., Atlas, t.* 37. *f.* 1.
Emys Spengleri, *Schweig.*, 32.
Hab. "in Chinâ," J. R. Reeves, Esq.

2. GEOEMYDA SPINOSA. *Geo. testâ suborbiculari, carinatâ; areolis spinâ centrali armatis; margine totâ profundè serratâ; suprà pallidè fuscâ, sterno pallidè fusco brunneo radiato; scutellis axillaribus inguinalibusque mediocribus.*

Emys spinosa, *Bell, Test., t. . fig.* 1, 2.—*Gray, Hardw. Ind. Zool., tom.* ii. *t. . fig.* 1.
Hab. "apud Penang," Capt. Hay.

A new genus of *Geckotidæ* is characterized by Mr. Gray under the name of

GEHYRA.

Digiti 5–5, ad basin dilatati, serie unicâ squamarum transversalium integrarum tecti, ad apicem compressi, liberi, omnes (præter pollices) unguiculati. Pori femorales nulli.

This genus is very nearly allied to *Platydactylus*, Cuv., in the

form of the base of the toes; but the ends of the toes are thin, simple, and compressed, instead of being more widely dilated, and with the last *phalanx* affixed along the upper surface. The body is covered with small uniform granular scales, and the belly with larger flat scales; the tail is ringed with square scales, those of the under surface being the largest.

GEHYRA PACIFICA. *Ge. pallidè brunnea albido punctata, subtùs alba; occipitis strigâ utrinque fasciisque latis irregularibus dorsalibus quinque vel sex pallidis; artubus pallido marmoratis.*

Long. *corporis* 2¾ poll.; *caudæ*, totidem.

Hab. in Insulâ quâdam Oceani Pacifici.

The collection of the British Museum contains a specimen, much discoloured, of what appears to be a second species of this genus. Another species is contained in the Muséum d'Histoire Naturelle at Paris.

A living specimen was exhibited of the *Red Viper* of the Somersetshire Downs. It had been sent from Taunton to Mr. Gray, who states that he has compared it very attentively with the *black* and with the *common Viper* of England, and that he cannot discover the slightest difference between them except in the shade of the colour. They all agree in having the upper lip shield white, with brown or black edges, and in having a series more or less distinct of lozenge-shaped spots. He consequently refers them all to *Vipera Berus*, Daud.

Mr. Gray also states that he believes the *Lacerta ædura*, described by the Rev. R. Sheppard in the seventh volume of the 'Linnean Transactions', to be the male, observed during the summer, of the common *Lacerta vivipara*, the *Lacerta agilis* of British authors; the several characters which were pointed out by Mr. Gray at the Meeting on May 22, 1832, (Lond. and Edin. Phil. Mag., vol. i. p. 461,) being at that season so fully developed as to produce the appearances noticed by Mr. Sheppard in his account of his presumed species.

Some notes were read of the dissection of a specimen of *Azara's Opossum, Didelphis Azaræ*, Temm., which recently died at the Society's Gardens. The general dissection was performed by Mr. Martin; that of the organs of generation by Mr. Rymer Jones.

The animal was an adult male, measuring, exclusive of the tail, 1 foot 5 inches, the tail being 1 foot 4 inches in length.

In illustration of the notes, which are printed in the "Proceedings," preparations were exhibited of the stomach and *cæcum*, as was also a drawing of the organs of generation and bladder.

ROYAL GEOLOGICAL SOCIETY OF CORNWALL.

Twenty-First Annual Report of the Council.

It is with great satisfaction that the Council have witnessed, during the past year, the re-establishment of the Quarterly Meetings, as proposed at the last anniversary. On these occasions the doors have been freely thrown open to all visitors without restriction:—and the officers have strenuously exerted themselves to impart in-

struction by the introduction of elementary essays at these meetings, in the hope of exciting a greater taste for geological pursuits.

A Report, read last year, on the Progress and Prospects of the Society, warmly advocated the importance of this measure, as a means of training up a succession of working Members to supply the places of those who are from time to time removed by various casualties:—and the anticipation of such losses has been fearfully realised during so short an interval. Mr. Giddy, who so long and ably filled the office of Curator, is no more!—and several distinguished Members, all formerly Vice-Presidents,—Sir Rose Price, Bart., Mr. Praed, and Mr. Humphry Grylls,—have also paid the debt of nature!

But we must not thus briefly pass over the death of our late excellent Curator,—his laborious and useful services justly merit our warmest gratitude. Mr. Giddy was one of the original Members of the Society, and up to the time of his decease, a period of twenty years, he continued to take an active part in the management of its affairs. He has not contributed any memoir to the Transactions; but to him we are solely indebted for the arrangement of the Museum, a service which must be esteemed as one of the most important that has been rendered to this Institution. His memory will be preserved in the Society's records as one of its first and most lamented benefactors,—and handed down to his successors in office, as an example worthy of their imitation.

By the departure of the Rev. George Pigott for India the Society has lost a Member whom it could but ill spare, as he had just entered on the active duties of a working geologist. And to add to this lengthened catalogue of casualties, a serious accident has for awhile deprived us of the valuable services of Mr. Carne; we have, however, the satisfaction to be able to look forward to his speedy restoration.

During the past year the apartments have been much improved and embellished:—and a great addition has been made to the cabinets in the back room, which is now entirely appropriated to the illustration of Cornish geology; and it is expected that in the course of the ensuing year this important department of the Museum will be completely arranged. It will be seen by the Curator's Report that the collection continues to receive considerable donations, the whole having amounted during the year to more than a thousand specimens: amongst these, two series from India, one from Mexico, and another from Brazil, may be more particularly specified.

Many works have been lately purchased for the library, including Sowerby's Mineral Conchology, and [G. B. Sowerby's] Genera of Recent and Fossil Shells. And Lindley and Hutton's Fossil Flora, and Agassiz's Researches on Fossil Fishes, now in progress of publication, have been ordered.

Mr. Henwood has at length terminated his survey of the mines: he will therefore now be able to arrange his extensive series of specimens, for which a distinct cabinet has been set apart. And he has promised to complete his paper on the Metalliferous Veins of Cornwall against the next anniversary;—by which time it is expected

that there will be sufficient materials for a fifth volume of Transactions:—indeed enough for this purpose has already been laid before the Society, but several of the communications made by Dr. Boase during the last year, have, with permission, been withdrawn and embodied in his recent publication on Primary Geology.

In conclusion, the Council have the pleasure to state that a larger annual accession of new Members has taken place than for many years past, and that the Funds, notwithstanding extraordinary disbursements, are adequate to meet the expenditure of the ensuing year. (By order,) HENRY S. BOASE,

October 10th, 1834. Secretary.

The following papers have been read since the last Report:—Remarks on a rare Granitic Rock found in the Walls of the Old St. Mary's Chapel, Penzance. By Henry S. Boase, M.D., Secretary of the Society.—On some curious Phænomena of Veins, recently observed in the Survey of the Cornish Mines. By W. J. Henwood, F.G.S., &c., Curator of the Museum.—Notice of a singular Vein in Huel Bosavern, St. Just. By Joseph Carne, Esq., F.R.S., F.G.S., M.R.I.A., &c. Treasurer of the Society.—Additional Observations on the Metalliferous Veins of Cornwall. By W. J. Henwood, F.G.S., &c.—On the Composition and Structure of the Granitic and Schistose Rocks at their Junction. By Henry S. Boase, M.D.—Details of some Experiments on the Horary Vibrations of the Magnetic Needle in vacuo, with a view to investigate the Question of the Diurnal Variation of Terrestrial Magnetism. By W. J. Henwood, F.G.S.—An Examination of the Cornish Slickensides, showing that they cannot be referred to a Mechanical Origin. By the same.—An Essay on the Nature of Stratification. By Henry S. Boase, M.D.—An Inquiry whether the Veins of Cornwall afford Evidences of Elevation or Subsidence of the Strata. By W. J. Henwood.—On the Fossil Bones of Pentuan Stream-work at present in the Museum. By R. Hocking, Esq., Member of the Society.—Notice of some Electro-magnetic Observations in Huel Jewel Copper Mine. By Robert Were Fox, Esq., Member of the Society.—A Sketch of the Geology of Forfarshire. By Henry S. Boase, M.D.—Remarks on the Theories of Mineral Veins. By Mr. Richard Tregaskis, Associate of the Society.—An Account of the Salt Springs and Rock Salt Formation of Hallein in Upper Austria. By John Armstrong, jun., Esq., Member of the Society.—Notice of the Effects of a Flash of Lightning at East Huel Crofty Mine. By W. J. Henwood.—Notice concerning the Nature of the Rocks in the Vicinity of Real del Monte. By Mr. John Rule, Camborne.—Notice of the Blasting of Rocks, with a Description of a new Fuse for igniting the Charge under water. By Mr. J. Hancock.—An Account of the Quantity of Tin produced in Cornwall and Devon, in the year ending with the Midsummer Quarter 1834. By Joseph Carne, Esq.—An Account of the Quantity of Copper produced in Cornwall, and in Great Britain and Ireland, in the year ending the 30th of June, 1834. By Alfred Jenkin, Esq.

At the Anniversary Meeting, held on the 10th of October, 1834, Davies Gilbert, Esq., D.C.L., F.R.S., &c., *President*, in the chair;—

the Report of the Council being read, it was resolved, that it be printed and circulated among the Members;—That a new class of Members be instituted under the designation of Corresponding Members. That the thanks of the Society be presented,—1. To the authors of the various papers: 2. To the donors of minerals, books, &c.: 3. To the officers of the Society. The President then on behalf of the Members presented to Dr. Boase the piece of plate, voted at the last meeting, as a testimonial of his long and valuable services in promoting the objects of the Society. In a complimentary address he alluded to Dr. Boase's late publication on Primary Geology, and expressed his opinion that, whether the views therein advanced should be ultimately substantiated or not, the discussion to which it will give rise cannot fail to prove beneficial to the progress of the science of geology.

The following gentlemen have been elected Members since the last Report:—*Honorary Members*: M. Elie de Beaumont; M. Ami Boué; M. Dufrénoy; M. Constant Prévost; Gideon Mantell, Esq., F.R.S., &c.; John Phillips, Esq., F.R.S., Professor of Geology, King's College, London:—*Ordinary Members*: Sir William Molesworth, Bart., M.P., Pencarrow; John Armstrong, jun., Esq., Penzance; John Batten, jun., Esq., Penzance; Michael La Beaume, Esq., London; Charles W. Boase, Esq., Dundee; Mr. John Chester, jun., Penzance; the Rev. Derwent Coleridge, Helston; William Cornish, jun., Esq., Penzance; Mr. James Flamank, Penzance; Henry Harvey, Esq., Hayle; Mr. William Petherick, Dolcoath; James Backwell Praed, Esq., Trevethow; the Rev. John Punnett, St. Erth; Francis Rodd, Esq.; William Carpenter Rowe, Esq., London; Mr. Charles Rule, Dolcoath; Richard S. Scott, Esq., Guernsey; James Trembath, jun., Esq., Sennen.—*Associates*: Mr. Francis Barratt, Pembroke; Mr. Henry Brenton, Tavistock; Mr. William Paull, Polgooth; Mr. Richard Tregaskis, Perran Wharf.

Officers and Council for the present year:—*President*: Davies Gilbert, Esq., D.C.L., F.R.S., &c. &c.:—*Vice-Presidents*: Samuel Borlase, Esq.; George Croker Fox, Esq., F.G.S., &c.; E. W.W. Pendarves, Esq., M.P., F.R.S.; James B. Praed, Esq.—*Secretary*: Henry S. Boase, M.D.—*Treasurer*: Joseph Carne, Esq.—*Curator*: W. J. Henwood, F.G.S.—*Librarian*: Richard Hocking, Esq.—*Council*: John Armstrong, jun., Esq.; John Batten, jun. Esq.; W. M. Boase, M.D.; John S. Enys, Esq.; Francis Paynter, Esq.; Richard Pearce, Esq.; Edward H. Rodd, Esq.; W. M. Tweedy, Esq.; John Vivian, Esq.; William Williams, Esq.

The Quarterly Meetings of the Society for the ensuing year will be held on Fridays,—the 23rd January, the 24th April, the 24th July, and the 6th November, at seven o'clock in the evening.

XXIV. *Intelligence and Miscellaneous Articles.*

COBALT BLUE COLOURS.

M. GAUDIN gives the following processes for preparing blue colours from oxide of cobalt:

Prepare borate of cobalt by adding a neutral salt of cobalt to one

of borate of soda; wash the precipitate slightly, and calcine it also slightly. Mix one part of this borate of cobalt with one or two parts of fused phosphate of soda, and heat the mixture to redness in a crucible. Phosphate of cobalt may be used instead of the borate, and a fine blue will be obtained. The phosphate of soda may be replaced by the arseniate

Borate of cobalt may be prepared as follows: Add an excess of borate of soda to a solution of a salt of cobalt, and a solution of carbonate of potash or soda, as long as a precipitate is formed. Wash, filter, and calcine slightly. Another blue may be formed by mixing twelve parts of phosphate of cobalt slightly calcined, twelve parts of fused phosphate of soda, two parts of fused borax, four parts of calcined alumina; and there may be added, if preferred, three parts of calcined carbonate of soda. Mix them intimately in a mortar, and heat to redness in a crucible. By this process a very fine blue is obtained.—*Journal de Pharmacie*, Sept. 1834, p. 536.

ON THE INFLUENCE OF ELECTRICITY IN GERMINATION. BY M. CHARLES MATTEUCCI.

Although the effect produced by electricity upon vegetation has long been a subject of inquiry, the greatest uncertainty still exists as to the nature of its action and the true influence which it exerts. The most recent work on this subject is by M. Becquerel, in which it is stated, that the act of germination always produces acetic acid. As, however, it is well known that the fecula of the cotyledons of leguminous and other grains undergoes changes analogous to those which it suffers by exposure to the air, it becomes a subject of interest to multiply the experiments on a great number of grains. Grains of wheat, hempseed, and lentils, &c., were made to germinate in well washed carbonate of lime. In a very short time acidity was developed; but the germination was allowed to go on for ten or twelve days. The carbonate of lime was then washed, the aqueous solution evaporated and treated with alcohol. The spirituous solution by evaporation yielded acetate of lime, muriate of soda, a saccharine substance, and gluten partly altered, in the greater number of cases: the hempseed alone gave a small quantity of acetate of lime only. It appears from this, that independently of the chemical action exercised by the gluten on the starch, in the simple act of germination there is always acetic acid developed. Regarding then, with M. Becquerel, the embryo and all that surrounds it as an electro-negative system which retains the bases and rejects the acids in the same manner as the negative pole of a pile, an experiment was made to try if it were possible by the aid of artificial electricity to assist or to contravene germination. With this view a pile of ten pairs of zinc and copper was prepared, and the positive pole was made to touch some lentil seeds, moistened with water, and the negative pole touched some others. Germination, indicated by acidity, was soon perceptible in the grains of the negative pole, while in those at the other pole it did not begin until long after. This result led to the idea that the action of the negative pole was derived from the alkali

separated at it, and this was proved to be the case by experiment. Lentil seeds were put to germinate in glasses of distilled water acidulated with nitric, acetic, and sulphuric acid, the temperature of the air being from 65° to 75° Fahrenheit: other seeds were put into water rendered alkaline by potash and ammonia. At the expiration of thirty hours, germination had very evidently commenced in the water rendered alkaline by potash: after forty-four hours it was much developed in this solution, in that of ammonia, and in water. In seven days some grains had germinated in the nitric and sulphuric acid, but even after a month had elapsed, none could be discovered in the acetic acid. It is a curious fact, that a grain which had germinated in the alkaline solution, was, after well washing, acid within. It is therefore to the action of the alkali that must be attributed the property of the negative pole to favour germination. To determine the action of metallic salts upon germination, acetate of lead, perchloride of mercury, nitrate of silver, and acetate of copper were employed: in solutions of these salts no germination occurred in ten days. In fact, after being well washed and put into water, they could not germinate at all. The same effect was produced by very concentrated solutions of common salt, and of muriate of barytes: in infusion of galls only did germination take place in the same way as in water.—*Ann. de Chim. et de Phys.*, t. lv., p. 310.

ON THE DETECTION OF OPIUM; AND ON A NEW TEST FOR MORPHIA AND QUINA. BY MR. H. A. MEESON.

To the Editors of the Philosophical Magazine.

GENTLEMEN,

In submitting to your consideration the following experiments, which are chiefly interesting in a medico-legal point of view, I shall not pretend to account for the chemical changes which take place, but shall confine myself to a description of the facts which I have observed. The detection of opium, in cases of poisoning by it, has always been attended with difficulty, and the addition of another test to those already employed may sometimes be found useful. The test which I am about to propose is applicable only to the principle Morphia. If a solution of this substance or of any of its salts be mixed with a strong solution of chlorine, and ammonia be added, a dark brown colour will pervade the solution, which will disappear by the addition of more of the solution of chlorine. This effect does not take place with any other of the vegetable alkalies which I have examined; but if quina or any of its salts be treated in the same way, a beautiful green colour will be observed, which will become red on the addition of an acid. This test is delicate, and will detect a grain of either of these alkaloids in a pint of solution. It is particularly necessary for the success of these reactions that both the chlorine and ammonia be strong.—Should these remarks meet your approbation, the insertion of them in your valuable Journal will much oblige, Your most obedient,

Guy's Hospital, Jan. 7, 1835. H. A. MEESON.

FALL OF A METEORITE IN MORAVIA.

At a quarter past six in the evening of the 25th of November 1833, M. Reichenbach witnessed the fall of a meteoric stone, accompanied by a brilliant light and a noise like thunder, in the neighbourhood of Blansko in Moravia. On account of the woody nature of the country he was unable to discover the principal mass; he succeeded, however, in finding some fragments, weighing about half a pound. These fragments resemble the stones that fell at Benares, L'Aigle, Berlongville, &c., so closely that they cannot be distinguished from them. According to Berzelius, 100 parts of the stone contain 17·15 meteoric iron separable by the magnet, containing small quantities of nickel, cobalt, tin, copper, sulphur, and phosphorus; 42·67 silicate of magnesia and protoxide of iron, in which the silica and base contain equal quantities of oxygen, together with some sulphuret of iron; 39·43 silicate of magnesia and protoxide of iron, mixed with silicates of potash, lime, and alumina, in which the silica contains twice as much oxygen as the bases; 0·75 chromate of oxide of iron mixed with oxide of tin. These proportions are subject to some variation in different portions of the stone.

100 parts of the meteoric iron contain

Iron	93·816
Nickel	5·053
Cobalt	0·347
Tin and copper	0·460
Sulphur	0·324
A trace of phosphorus.	

The remaining, or stony portion of the mass is partly soluble in hydrochloric acid. One portion of it consisted of 51·5 soluble and 48·5 insoluble matter; another of 48·9 soluble and 51·1 insoluble.

The soluble part consists of

Silica	33·084
Magnesia	36·143
Protoxide of iron	26·935
Oxide of manganese	0·465
Oxide of nickel, containing tin and copper	0·465
Alumina	0·329
Soda	0·857
Potash	0·429
Loss (principally sulphur)	1·273

The insoluble part contains

Silica	57·145
Magnesia	21·843
Lime	3·106
Protoxide of iron	8·592
Oxide of manganese	0·724
Oxide of nickel, containing tin and copper	0·021
Alumina	5·590
Soda	0·931
Potash	0·010
Chromate of iron, containing tin	1·533
Loss	0·505

Poggendorff's Annalen.

Meteorological Observations made by Mr. THOMPSON *at the Garden of the Horticultural Society at Chiswick, near London, and by Mr.* VEALL, *at Boston.*

Days of Month. 1834.	Barometer. London. Max.	Barometer. London. Min.	Barometer. Boston. 8½ A.M.	Thermometer. London. Max.	Thermometer. London. Min.	Thermometer. Bost. 8½ A.M.	Wind. Lond.	Wind. Bost.	Rain. Lond.	Rain. Bost.
Dec. 1	29·478	29·268	28·73	56	43	50	W.	NW.	0·02	0·32
2	30·028	29·605	28·94	52	33	48·5	W.	NW.	...	...
3	30·195	30·110	29·09	49	45	45	W.	calm	...	...
4	30·187	30·171	29·66	51	30	48	SE.	calm	...	...
5	30·220	30·194	29·70	50	28	47	SW.	calm	...	...
6	30·240	30·219	29·68	55	47	46	SW.	W.	·01	...
7	30·192	30·081	29·60	55	43	52	SW.	calm	·14	...
☾ 8	30·499	30·268	29·65	46	33	41	W.	NW.	...	·03
9	30·569	30·411	30·04	46	33	37	SW.	calm	·19	...
10	30·512	30·307	29·80	46	28	40	W.	NW.	...	·18
11	30·646	30·613	30·11	45	28	32	SW.	calm	...	...
12	30·551	30·468	30·01	46	33	38	W.	calm	...	...
13	30·523	30·502	30·11	45	32	41·5	NE.	calm	...	...
14	30·611	30·564	30·20	41	35	35	NE.	calm	...	...
15	30·667	30·622	30·24	44	40	42	NE.	calm	...	...
○ 16	30·648	30·567	30·10	46	38	43	NE.	calm	...	...
17	30·220	30·165	29·73	46	39	43	N.	calm	·04	...
18	30·445	30·333	29·90	45	31	42·5	NE.	calm	...	·07
19	30·463	30·446	30·00	44	40	41	NE.	calm	...	·04
20	30·425	30·401	29·93	44	38	40	NE.	calm	...	...
21	30·437	30·411	29·88	46	36	38	SW.	calm	...	...
22	30·568	30·547	30·03	43	27	33	N.	W.	...	...
☽ 23	30·558	30·534	30·10	41	25	32·5	N.	NW.	...	...
24	30·550	30·441	30·07	39	30	30	SW.	W.	...	...
25	30·496	30·407	29·90	46	35	40	NW.	calm	...	...
26	30·591	30·483	30·18	43	31	40	NE.	calm	...	...
27	30·610	30·576	30·19	42	30	35	SE.	calm	...	...
28	30·492	30·372	30·04	42	27	39	SE.	calm	...	...
29	30·243	30·121	29·83	46	39	33·5	S.	W.	·03	...
● 30	30·005	29·913	29·44	55	50	49	SW.	calm	·07	...
31	29·860	29·823	29·26	53	43	55	SW.	calm	·24	...
	30·667	29·268	29·81	56	25	41·2			0·74	0·64

Remarks.

London.—December 1. Stormy and wet: fine. 2—4. Fine. 5, 6. Foggy. 7. Rain, with stormy wind. 8. Very clear. 9. Fine. 10. Clear. 11. Frosty: fine. 12. Frosty: fine: hazy. 13. Slight haze: clear and frosty at night. 14. Overcast. 15, 16. Hazy. 17. Clear and windy. 18. Clear and fine. 19—21. Overcast and fine. 22. Very fine: clear and frosty at night. 23. Sharp frost: very fine: clear and frosty. 24. Frosty and foggy: very fine. 25. Slight haze: very fine. 26. Fine: cloudy and cold: hazy. 27. Dense fog. 28. Very fine. 29. Hoar frost: fine. 30. Overcast: rain. 31. Heavy rain.

Boston.—December 1. Cloudy: rain early A.M. 2. Stormy. 3. Fine. 4—6. Cloudy. 7. Cloudy: rain P.M. 8. Stormy: snow A.M. 9. Fine. 10. Fine: rain early A.M. 11, 12. Fine. 13. Cloudy. 14. Fine. 15. Foggy. 16. Fine. 17. Cloudy: rain A.M. 18. Fine: rain A.M. 19, 20. Cloudy. 21—24. Fine. 25, 26. Cloudy. 27. Fine. 28. Cloudy. 29. Fine. 30. Cloudy. 31. Cloudy: three degrees warmer than 27th August last.

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[THIRD SERIES.]

MARCH 1835.

XXV. *Observations on the supposed Achromatism of the Eye.* *By* Sir David Brewster, F.R.S., &c.

IN a paper "*On the Achromatism of the Eye*," by the Rev. Baden Powell, just published by the Ashmolean Society of Oxford, he has endeavoured to refute the opinions and statements of different authors who have maintained that the eye is not an achromatic instrument. As Mr. Powell has referred to opinions and experiments of mine upon this subject, I feel myself called upon either to renounce them, if they are wrong, or to endeavour to explain and support them if they are correct.

The experiment on the marginal dispersion of my own eye, quoted by Mr. Powell, is admitted by him to be so far decisive of the question as to prove "*that the principle of its achromatism* (if it exist) *must be such as is not effective in oblique excentrical pencils*," p. 11; but he is of opinion, that notwithstanding this, the eye may be *in general* achromatic for *direct* rays.

In order to establish this opinion, Mr. Powell discusses some very decisive experiments of Fraunhofer, which I published in the *Edinb. Phil. Journal*, No. xix. p. 35. The objections which he makes to these experiments do not, in my opinion, invalidate the results which their illustrious author deduced from them; and I have every confidence in the conclusion at which he arrives, that, in his eye, *blue* rays must *diverge* from a point 21·1* inches distant, in order to have

* This is the mean of *four* experiments.

the same focus as *parallel red* rays. In support of this opinion I may adduce the experimental testimony of Dr. Wollaston and Dr. Young. In order to prove "the dispersive power of the eye," Dr. Wollaston "looks through a prism at a small lucid point, which of course becomes a linear spectrum. But the eye cannot so adapt itself as to make the whole spectrum appear a line; for if the focus be adapted to collect the *red* rays to a point, the *blue* will be too much refracted, and expand into a surface; and the reverse will happen if the eye be adapted to the *blue* rays; so that in either case the line will be seen as a triangular space." To this interesting observation Dr. Young adds the following experiments. "The observation is confirmed by placing a small concave speculum in different parts of a prismatic spectrum, and ascertaining the utmost distances at which the eye can collect the rays of different colours to a focus. By these means I find *that the red rays, from a point at 12 inches' distance, are as much refracted as white or yellow light at 11.* The difference is equal to the refraction of a lens 132 inches in focus*."

In a subsequent paper, "*On some cases of the Production of Colour*," (Lectures, vol. ii. p. 638,) Dr. Young informs us that he has confirmed his previous observations on the dispersive powers of the eye: "I find," says he, "that at the respective distances of 10 and 15 inches the extreme *red* and the extreme *violet* rays are similarly refracted, the difference being expressed by a focal length of 30 inches. Now the interval between *red* and *yellow* is about one fourth of the whole spectrum; consequently, a focal length of 120 inches expresses a power equivalent to the dispersion of the *red* and *yellow*, and this differs but little from 132, which was the result of the observation already described. I do not know that these experiments are more accurate than the former one; but I have repeated them several times under different circumstances, and I have no doubt that the dispersion of coloured light in the human eye is nearly such as I have stated it. It may also be ascertained very accurately, by looking through an aperture, of known dimensions, at the image of a point dilated by a prism into a spectrum, and measuring the angle formed by its sides on account of the difference of refrangibility of the rays; and this method seems to indicate *a greater dispersive power* than the former."

When Dr. Wells, as quoted by Mr. Powell, states "that the eye has no principle of achromatic compensation in its lens, since the refractions are all performed one way," he would be

* On the Mechanism of the Eye: Lectures, vol. ii. pp. 584, 585.

right in his argument, if his facts were correct. The refractions are *not all performed one* way. The vitreous humour acts as a concave lens, and the rays are refracted *from* the axis in passing from the capsule of the crystalline into the vitreous humour, and, as Mr. Powell justly observes, this case is precisely the same *in principle* as the construction for achromatic microscopes which I have given in p. 408 of my *Treatise on New Philosophical Instruments.* But in practice it is very different. The refractive and dispersive powers of the crystalline and vitreous humours are such *that an achromatic compensation is impossible.*

But there is another point of view in which I would beg to submit this subject to Mr. Powell's consideration. I have elsewhere stated, (and Mr. Powell has quoted the passage without pursuing the idea which it contains,) "that no provision is made in the human eye for the correction of colour, *because the deviation of the differently coloured rays is too small to produce indistinctness of vision.*" If the last of these two propositions be true, the first will be instantly admitted; for it is inconceivable that the all-wise Author of nature, who never works in vain, should have made the eye achromatic when it was not required for the purposes of vision.

The idea that the eye would answer the purposes of vision more perfectly if it were achromatic, seems to be founded on a hasty analogy. Because an achromatic telescope, or microscope, or lens, is preferable to the same instruments when they are not freed from colour, it is conceived that an achromatic eye should have the same superiority: the two cases, however, are considerably different. In using the telescope, &c., the eye views in succession every part of the image which they form, in every part of the object within the field of view; but there is no eye behind the retina to view in the same manner the image which is formed upon that membrane. In point of fact, *the eye is incapable of seeing any object distinctly* unless *it is situated in or near its axis*, and hence it is of no importance whatever to render the image distinct at a distance from the axis. Whenever the eye wishes to examine an object, or a part of an object, minutely, it instantly directs to it the axis of its vision, and from the rapidity of its movements, and the duration of the impressions of light, it thus obtains the most perfect view of a given object, and can scrutinize in succession its minutest parts.

Now in order to obtain distinct, and a *sensibly colourless* vision, near the axis of the eye, achromatic compensation is not necessary. In order to prove this, look through a convex lens, about an inch in focal length, at any sharp and well-

defined dark object on a luminous ground, and the most perfect and colourless vision of this object will be obtained in and near the common axis of the eye and the lens. Now in this case we have *sensibly colourless* vision, although the lens is not achromatic, and although its chromatic aberration is increased by whatever colour there may be in the eye itself. How much more, then, should vision be *sensibly colourless near the axis of vision*, and with the eye alone, when we consider that it is composed of substances which have a much lower dispersive power than glass!

Mr. Powell has quoted the admirable paper of Dr. Maskelyne, in which, without referring to the physiological fact on which I have proceeded, he regards the eye as a lens, and calculates the amount of indistinctness in the image which it forms. He has shown that the calculated dispersion, which we believe to be even less than he makes it, is not incompatible with distinct vision, and he has pointed out causes which tend to diminish the injurious effects of this dispersion. But though Mr. Powell quotes these results, he does not attempt to call them in question, or to disprove them by other calculations founded on more recent measures of dispersive power; and until this is done, great weight must be attached to the reasoning of Dr. Maskelyne.

After a careful perusal of Mr. Powell's Memoir, I have no hesitation in stating that I continue to maintain the opinions which, along with others, I have published on this subject; and that I consider the *non-achromatism of the eye* as a fact as well established as any other fact in natural philosophy.

Belleville, January 15th, 1835.

XXVI. *On the General Existence of a newly observed and peculiar Property in Plants, and on its Analogy to the Irritability of Animals. By* Henry Johnson, *M.D.**

I DO not know that it has ever been remarked, that, on dividing the stem of almost any herbaceous plant, a singular separation of the divided segments uniformly occurs, and that this separation continues until the stem withers and dies from the loss of its moisture.

It was in the autumn of 1827 that I first observed this fact; and from an opinion which at once occurred to me that it was connected with the motive powers of the plant, I have been induced, since that period, to pay much attention to the

* Communicated by the Author. This paper is an abstract of a Memoir read before the Ashmolean Society of Oxford.

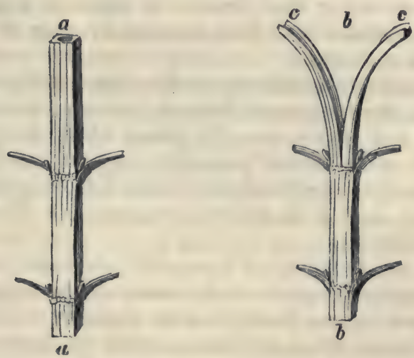
subject, and to perform very numerous experiments, with a view to learn its peculiar nature and effects. It will be my business in the following pages to state, as succinctly as possible, some of the results of my inquiries.

To the phænomenon above mentioned, I have hitherto applied the term *divergence*, under which appellation I shall here continue to speak of it. But, as the evidence which I am about to adduce has convinced me of the analogy, if not the identity, of this property with what physiologists call *irritability**, I shall in future venture to consider them as similar principles, and substitute the word irritability for that of divergence.

The experiments which follow will afford a sufficient illustration of the phænomena of divergence.

Exp. 1. A portion of the stem of a White Dead-Nettle (*Lamium album*), was divided at one extremity with a lancet, the division being carried to the length of 1½ inch. The segments instantly separated from each other *one inch*, which gradually increased to 1⅝ inch. The sketch, fig. 1. will serve to show the appearances which presented themselves, *a a* being the stem previously to, *b b* the same after division, *c c* the divided segments in a state of divergence.

Fig. 1.



Exp. 2. A slender spray of Yellow Jessamine was divided down the middle. The two segments instantly separated from each other, and remained so when the spray was held in an inverted position; thus showing that the effect did not depend on the weakened segments bending outwards from

* See System of Physiology, by J. Bostock, M.D., vol. i. p. 160.

their own weight. Fig. 2. *a*, represents the stem in its proper, *b* in an inverted position.

a Fig. 2. *b*

By experiments similar to the preceding, I have detected this property in above seventy different *genera* of plants, a table of which is now beside me, but which would occupy too much room to be here inserted.

Divergence being thus proved to exist very generally in plants, let us, in the next place, endeavour to learn something of its nature and cause.

After carefully considering all the observed facts, I am led to conclude, that they must depend, either on physical elasticity, or on that vital contractile power which is called irritability. No other known principle suggests itself to which I can reasonably ascribe them. The following facts prove, I think, very clearly that the phænomena of divergence are not due to elasticity.

1. The woody parts of trees, and even the rattan cane, which are certainly some of the most elastic vegetable substances, never exhibit divergence on division*.

2. The stems of many plants which in their recent and growing state are divergent on division, lose this property when they become dead and dried, although they are in the latter case much more elastic than before. For example, the stem of the Common Teasel (*Dipsacus fullonum*), which is strongly divergent in its recent green state, loses this property

[* A botanical friend suggests the inquiry whether Dr. Johnson has ever tried the effect of division on *Dirca palustris*, or any plant of the natural order *Thymelææ*?—Edit.]

entirely when it has become dry and *weathered* (as geologists would say) by exposure in our hedges through the winter. But, in the latter case, it is most certainly much more elastic than when alive and growing.

3. Lastly, Poisons destroy the power of divergence, which they would not do if it were dependent on a mere physical cause such as elasticity. This fact I state on the authority of very numerous experiments, which it seems needless to relate circumstantially.

I infer, then, from the preceding facts and arguments, that elasticity is not the cause of divergence. I proceed, in the next place, to state the experiments and observations which lead me to conclude that it is a *vital* property.

1. It is most active in those parts of plants which exhibit other vital properties and functions in the greatest perfection. For instance, whilst, as I have stated above, it does not exist in dead wood, and ceases as a plant loses its moisture, it is found in stems, and flower- and leaf-stalks when in their most vigorous and healthy state.

2. If the opinion, that this property is of a vital nature, were correct, I thought it would be destroyed by poisons, and this I find to be the case whether a plant be supplied with a poisonous liquid instead of water, or a divergent stem totally immersed in such a liquor. I shall give the following experiments in proof of this.

Exp. 3. A stem of Bryony (*Bryonia dioica*) was placed in a solution of arsenite of potash*. In two days it became so flaccid that the head and tendrils hung downwards. They were not discoloured, and but little shrivelled. The divergent power was completely destroyed.

Exp. 4. I confined two stems of a Red Dead-Nettle (*Lamium purpureum*) in an inverted jar filled with sulphuretted hydrogen. In two days one of the stems was so perfectly flaccid as to be incapable of holding up its head. They were not withered, and the blossoms only looked a little paler. Every part of the stems which was exposed to the influence of the gas had completely lost its divergent power.

3. The following experiments show that the divergent power is capable of being excited or increased by stimulants.

Many poisons, whose ultimate effect is to destroy this property, do at first increase it. This has occurred with laurel-water, dilute nitric acid, brandy, oil of turpentine, hot water, and a mixture of æther with sal volatile. Cold water, also, so augments the divergence of the segments of a divided stem,

* Made by boiling together in 1℥ of water 8 grains of white arsenic and the same quantity of subcarbonate of potash.

that they become curled up in circles or spiral coils. Every one has seen an instance of this sort in the case of common celery when dressed for the table. More remarkable proofs of stimulation are, however, afforded in the following experiments.

Exp. 5. Several pieces of the stems of different plants were divided, and, in a state of divergence, were immersed in hot water. The divergence was at first increased in all, but in a few minutes they entirely collapsed; and their divergence was totally destroyed.

Fig. 3.

Exp. 6. I procured a young and vigorous flower-stalk of the Common Dandelion (*Leontodon Taraxacum*) which curved considerably to the *left* side, fig. 3. Several notches (*a*, *a*, *a*, *a*,) were then made in the concave side, extending towards the axis of the flower-stalk. The latter instantly became erect! and, on cautiously applying a red-hot poker near to the entire side, the fibres in the latter appeared to be contracted, and the stem was now drawn towards that side (*i. e.* to *h*), *the right*; namely, the opposite to that to which it inclined at first.

Having concluded from the arguments above stated (pp. 166 and 167,) that divergence is the result of a living or vital action, we learn, from Experiments 3 and 4, that it is entirely destroyed by poisons, which is what might be expected to take place if this supposition were well founded. If to this any one should object, that even physical properties such as elasticity, that of a quill for example, may be destroyed by poisonous liquids which have also chemical effects; I answer, that the objection has been already foreseen, and is in my opinion completely refuted, by the fact, that similar effects are produced by laurel-water, and even by sulphuretted hydrogen gas, which have little *chemical* activity.

There can be no doubt, therefore, that poisonous liquids act on plants as *vital agents* in the same way as that in which they would act on the living system of animals*. When it is proved, also, by Experiments 5 and 6, that stimulants act on parts endowed with this property, just as they would do on

* It appears from Dr. Christison's Work on Poisons, that it occasionally happens when these agents are taken into the stomach that the contractility of the muscles is destroyed.

the contractile organs of animals, as the heart and other muscles, it seems to me to be a legitimate inference from all which has been said, that divergence is a vital action, and in every sense analogous to the *contractility* or *irritability* of the animal system.

In a future communication I shall endeavour to extend this analogy, by showing that the motions of plants may be traced to this same property, as those of animals are to irritability*.

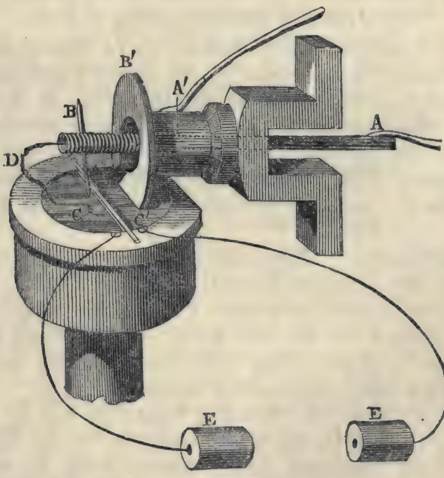
Shrewsbury, Oct. 6, 1834.

XXVII. *On a new Phænomenon in Magneto-Electricity.* *By Mr.* Edward M. Clarke.

To the Editors of the Philosophical Magazine and Journal.

Gentlemen,

HAVING for some time past been engaged in the manufacture of the new magnetic electrical machines, in their completion and in the subsequent trials of their action I have observed a phænomenon which I have not anywhere seen an account of. I shall describe the effect as briefly as I can: in order to do this I have furnished a diagram of part of the machine.



[* We are indebted to a medical friend for the remark, that the phænomenon described by Dr. Johnson most closely resembles the contraction of the *ligamentum nuchæ*, by which the head of animals is retracted after death, and which Bichat attributes to vital contractility, which he regards as a distinct property.—Edit.]

A represents the commencement of the collecting wire coils in connexion with the rotating pointed piece B, dipping into and leaving the mercury C simultaneously with the movement of the collecting coils on the rotating armature of the magnet. A′ represents the terminations of the collecting coils in connexion with the rotating disk B′, which is always in the mercury C′; D, a copper wire in contact with the mercury C, the point of which is in contact with the wire that carries the pointed piece B. The director wires, E E′, are represented as in connexion with each portion of mercury, and of course in connexion with the collecting wire coils. On holding the directors E E′ in the wetted hands, a slight continuous thrilling sensation is felt; but if they are brought into contact and then separated, on the moment of their separation a powerful instantaneous shock is felt passing through the arms. The same effect is produced if you remove the pointed piece B. A continued scintillation and combustion of steel wire and surfaces, or of other metals, can be produced by substituting them for the directors E E′.

39, Charles Street, Parliament Street, January 13, 1835. EDWARD M. CLARKE.

XXVIII. *Note relative to the Form of the Fibres of Cotton. By* JAMES THOMSON, *Esq., F.R.S.*

IN the first volume of the *Bulletin de la Société Industrielle de Mulhausen*, is a memoir by M. Josué Heilman, entitled "Observations microscopiques sur la forme, la finesse, et la force des filamens de Coton," in which he ascribes to the fibres of cotton the precisely same form as that given to them in the drawing of Mr. Bauer, dated February 11, 1822, which accompanies my paper on Mummy Cloth, Lond. & Edin. Phil. Mag. vol. v. p. 355.

Mr. Heilman's "Observations" are accompanied by a drawing by Mr. Edward Koechlin, of these fibres. Whoever will take the trouble to compare the two drawings will *detect internal evidence of the one being derived from the other.* Mr. Heilman's paper being published in 1828, and mine in 1834, renders some explanation necessary.

In 1822 or 1823, Mr. Edward Koechlin was in England, and during a visit he made to Primrose, he saw Mr. Bauer's drawing, and requested permission to copy it, which was granted. It is from this drawing and Mr. Koechlin's communication that Mr. Heilman's "Observations microscopiques" are derived. The paltry fraud of appropriating to

* Communicated by the Author.

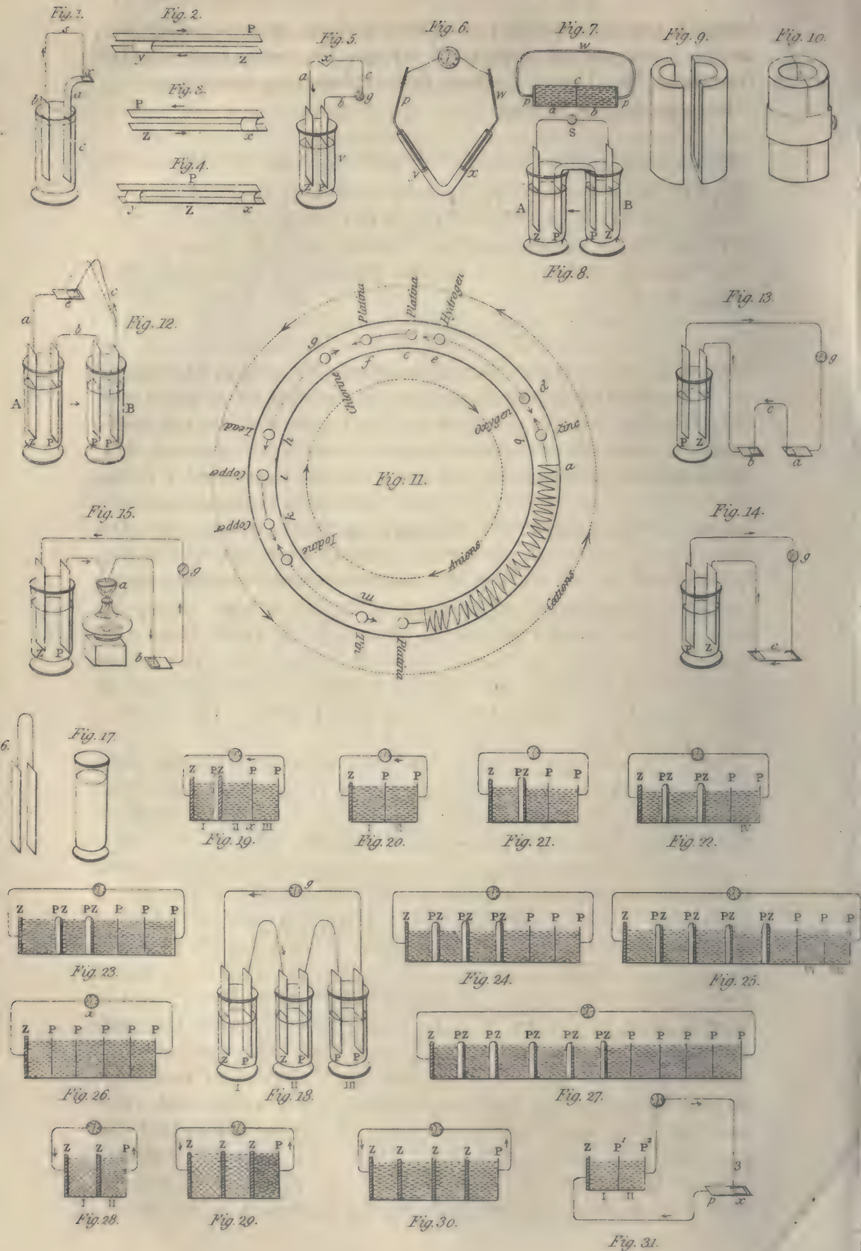


Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8.
Fig. 9.
Fig. 10.
Fig. 11.
Platina
Platina
Hydrogen
Chlorine
Oxygen
Zinc
Lead
Copper
Copper
Iodine
Anions
Cations
Tin
Platina
Fig. 12.
Fig. 13.
Fig. 14.
Fig. 15.
Fig. 17.
Fig. 18.
Fig. 19.
Fig. 20.
Fig. 21.
Fig. 22.
Fig. 23.
Fig. 24.
Fig. 25.
Fig. 26.
Fig. 27.
Fig. 28.
Fig. 29.
Fig. 30.
Fig. 31.

himself the observations of others without acknowledgement, might have passed unnoticed by me for ever, had not the friends of Mr. Bauer deemed this explanation necessary.

Primrose, January 31, 1835.

XXIX. *Experimental Researches in Electricity.—Eighth Series. By* MICHAEL FARADAY, *D.C.L. F.R.S. Fullerian Prof. Chem. Royal Institution, Corr. Memb. Royal and Imp. Acadd. of Sciences, Paris, Petersburgh, Florence, Copenhagen, Berlin, &c. &c.*

[Continued from p. 133.]

935. IN order to put the equal and similar action of acid and alkali to stronger proof, arrangements were made as in (Plate I.) fig. 8.; the glass vessel A contained dilute sulphuric acid, the corresponding glass vessel B solution of potassa, P P was a plate of platina dipping into both solutions, and Z Z two plates of amalgamated zinc connected with a delicate galvanometer. When these were plunged at the same time into the two vessels, there was generally a first feeble effect, and that in favour of the alkali, i. e. the electric current tended to pass through the vessels in the direction of the arrow, being the reverse direction of that which the acid in A would have produced alone: but the effect instantly ceased, and the action of the plates in the vessels was so equal, that, being contrary, because of the contrary position of the plates, no permanent current resulted.

936. Occasionally a zinc plate was substituted for the plate P P, and platina plates for the plates Z Z; but this caused no difference in the results: nor did a further change of the middle plate to copper produce any alteration.

937. As the opposition of electro-motive pairs of plates produces results other than those due to the mere difference of their independent actions (1011. 1045.), I devised another form of apparatus, in which the action of acid and alkali might be more directly compared. A cylindrical glass cup, about two inches deep within, an inch in internal diameter, and at least a quarter of an inch in thickness, was cut down the middle into two halves, fig. 9. A broad brass ring, larger in diameter than the cup, was supplied with a screw at one side; so that when the two halves of the cup were within the ring, and the screw was made to press tightly against the glass, the cup held any fluid put into it. Bibulous paper of different degrees of permeability was then cut into pieces of such a size as to be easily introduced between the loosened halves of the

cup, and served when the latter were tightened again to form a porous division down the middle of the cup, sufficient to keep any two fluids on opposite sides of the paper from mingling, except very slowly, and yet allowing them to act freely as one *electrolyte.* The two spaces thus produced I will call the cells A and B, fig. 10. This instrument I have found of most general application in the investigation of the relation of fluids and metals amongst themselves and to each other. By combining its use with that of the galvanometer, it is easy to ascertain the relation of one metal with two fluids, or of two metals with one fluid, or of two metals and two fluids upon each other.

938. Dilute sulphuric acid, sp. gr. 1·25, was put into the cell A, and a strong solution of caustic potassa into the cell B; they mingled slowly through the paper, and at last a thick crust of sulphate of potassa formed on the side of the paper next to the alkali. A plate of clean platina was put into each cell and connected with a delicate galvanometer, but no electric current could be observed. Hence the *contact* of acid with one platina plate, and [of] alkali with the other, was unable to produce a current; nor was the combination of the acid with the alkali more effectual (925.).

939. When one of the platina plates was removed and a zinc plate substituted, either amalgamated or not, a strong electric current was produced. But, whether the zinc were in the acid whilst the platina was in the alkali, or whether the reverse order were chosen, the electric current was always from the zinc through the electrolyte to the platina, and back through the galvanometer to the zinc, the current seeming to be strongest when the zinc was in the alkali and the platina in the acid.

940. In these experiments, therefore, the acid seems to have no power over the alkali, but to be rather inferior to it in force. Hence there is no reason to suppose that the combination of the oxide formed with the acid around it has any direct influence in producing the electricity evolved, the whole of which appears to be due to the oxidation of the metal (919.).

941. The alkali, in fact, is superior to the acid in bringing a metal into what is called the positive state; for if plates of the same metal, as zinc, tin, lead, or copper, be used both in the acid or alkali, the electric current is from the alkali across the cell to the acid, and back through the galvanometer to the alkali, as Sir Humphry Davy formerly stated*. This current is so

* Elements of Chemical Philosophy, p. 149; or Philosophical Transactions, 1826, p. 403. [or Phil. Mag. and Annals, N.S., vol. i. p. 101.]

powerful, that if amalgamated zinc, or tin, or lead be used, the metal in the acid evolves hydrogen the moment it is placed in communication with that in the alkali,—not from any direct action of the acid upon it, for if the contact be broken the action ceases,—but because it is powerfully negative with regard to the metal in the alkali.

942. The superiority of alkali is further proved by this, that if zinc and tin be used, or tin and lead, whichever metal is put into the alkali becomes positive, that in the acid being negative. Whichever is in the alkali is oxidized, whilst that in the acid remains in the metallic state, as far as the electric current is concerned.

943. When sulphuretted solutions are used (930.) in illustration of the assertion, that it is the chemical action of the metal and one of the *ions* of the associated electrolyte that produces all the electricity of the voltaic circuit, the proofs are still the same. Thus, as Sir Humphry Davy* has shown, if iron and copper be plunged into dilute acid, the current is from the iron through the liquid to the copper: in solution of potassa it is in the same direction, but in solution of sulphuret of potassa it is reversed. In the first two cases it is oxygen which combines with the iron, in the latter sulphur which combines with the copper, that produces the electric current; but both of these are *ions*, existing as such in the electrolyte, which is at the same moment suffering decomposition; and, what is more, both of these are *anions*, for they leave the electrolytes at their *anodes*, and act just as chlorine, iodine, or any other *anion* would act which might have been previously chosen as that which should be used to throw the voltaic circle into activity.

944. The following experiments complete the series of proofs of the origin of the electricity in the voltaic pile. A fluid amalgam of potassium, containing not more than a hundredth of that metal, was put into pure water, and connected through the galvanometer with a plate of platina in the same water. There was immediately an electric current from the amalgam through the electrolyte to the platina. This must have been due to the oxidation only of the metal, for there was neither acid nor alkali to combine with, or in any way act on, the body produced.

945. Again, a plate of clean lead and a plate of platina were put into *pure* water. There was immediately a powerful current produced from the lead through the fluid to the platina: it was even intense enough to decompose solution of the iodide

* Elements of Chemical Philosophy, p. 148.

of potassium when introduced into the circuit in the form of apparatus already described (880.), fig. 1. Here no action of acid or alkali on the oxide formed from the lead could supply the electricity: it was due solely to the oxidation of the metal.

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946. There is no point in electrical science which seems to me of more importance than the state of the metals and the electrolytic conductor in a simple voltaic circuit *before and at* the moment when metallic contact is first completed. If clearly understood, I feel no doubt it would supply us with a direct key to the laws under which the great variety of voltaic excitements, direct and incidental, occur, and open out various new fields of research for our investigation.

947. We seem to have the power of deciding to a certain extent in numerous cases of chemical affinity, (as of zinc with the oxygen of water, &c. &c.) which of *two modes of action of the attractive power* shall be exerted (996.). In the one mode we can transfer the power onwards, and make it produce elsewhere its equivalent of action (867. 917.); in the other, it is not transferred, but exerted wholly at the spot. The first is the case of volta-electric excitation, the other ordinary chemical affinity; but both are chemical actions and due to one force or principle.

948. The general circumstances of the former mode occur in all instances of voltaic currents, but may be considered as in their perfect condition, and then free from those of the second mode, in some only of the cases; as in those of plates of zinc and platina in solution of potassa, or of amalgamated zinc and platina in dilute sulphuric acid.

949. Assuming it sufficiently proved, by the preceding experiments and considerations, that the electro-motive action depends, when zinc, platina, and dilute sulphuric acid are used, upon the mutual affinity of the metal zinc and the oxygen of the water (921. 924.), it would appear that the metal, when alone, has not power enough, under the circumstances, to take the oxygen and expel the hydrogen from the combination; for, in fact, no such action takes place. But it would also appear that it has power so far to act, by its attraction for the oxygen of the particles in contact with it, as to place the similar forces already active between these and the other particles of oxygen and the particles of hydrogen in the water, in a peculiar state of tension or polarity, and probably also at the same time to throw those of its own particles which are in contact with the water into a similar but opposed state. Whilst this state is retained, no further change occurs; but when it is relieved, by completion of the circuit, in which

case the forces determined in opposite directions, with respect to the zinc and the electrolyte, are found exactly competent to neutralize each other, then a series of decompositions and recompositions takes place amongst the particles of oxygen and hydrogen constituting the water, between the place of relief and the place where the zinc is active; these intervening particles being evidently in close dependence upon and relation to each other. The zinc forms a direct compound with those particles of oxygen which were, immediately before, in divided relation to both it and the hydrogen: the oxide is removed by the acid, and a fresh surface of contact between the zinc and water is presented, to renew and repeat the action.

950. Practically, the state of tension is best relieved by dipping a metal which has less attraction for oxygen than the zinc, into the dilute acid, and making it also touch the zinc. The force of chemical affinity, which has been influenced or polarized in the particles of the water by the dominant attraction of the zinc for the oxygen, is then transferred, in a most extraordinary manner, through the two metals, so as to re-enter upon the circuit in the electrolytic conductor, which cannot convey or transfer it without decomposition as the metals can; or rather, probably, it is exactly balanced and neutralized by the force which at the same moment completes the combination of the zinc with the oxygen of the water. The forces, in fact, of the two particles which are acting towards each other, and which are therefore in opposite directions, are the origin of the two opposite forces, or directions of force, in the current. They are of necessity equivalent to each other. Being transferred forward in contrary directions, they produce what is called the voltaic current: and it seems to me impossible to resist the idea that it must be preceded by a *state of tension* in the fluid, and between the fluid and the zinc; the *first consequence* of the affinity of the zinc for the oxygen of the water.

951. I have sought carefully for indications of a state of tension in the electrolytic conductor; and conceiving that it might produce something like structure, either before or during its discharge, I endeavoured to make this evident by polarized light. A glass cell, seven inches long, one inch and a half wide, and six inches deep, had two sets of platina electrodes adapted to it, one set for the ends, and the other for the sides. Those for the *sides* were seven inches long by three inches high, and when in the cell were separated by a little frame of wood covered with calico; so that when made active by connexion with a battery upon any solution in the cell,

the bubbles of gas rising from them did not obscure the central parts of the liquid.

952. A saturated solution of sulphate of soda was put into the cell, and the electrodes connected with a battery of 150 pairs of 4-inch plates: the current of electricity was conducted across the cell so freely, that the discharge was as good as if a wire had been used. A ray of polarized light was then transmitted through this solution, directly across the course of the electric current, and examined by an analysing plate; but though it penetrated seven inches of solution thus subject to the action of the electricity, and though contact was sometimes made, sometimes broken, and occasionally reversed during the observations, not the slightest trace of action on the ray could be perceived.

953. The large electrodes were then removed, and others introduced which fitted the *ends* of the cell. In each a slit was cut, so as to allow the light to pass. The course of the polarized ray was now parallel to the current, or in the direction of its axis (517.); but still no effect, under any circumstances of contact or disunion, could be perceived upon it.

954. A strong solution of nitrate of lead was employed instead of the sulphate of soda, but the results were equally negative.

955. Thinking it possible that the discharge of the electric forces by the successive decompositions and recompositions of the particles of the electrolyte might neutralize and therefore destroy any effect which the first state of tension could by possibility give, I took a substance which, being an excellent electrolyte when fluid, was a perfect insulator when solid, namely, borate of lead, in the form of a glass plate, and connecting the sides and the edges of this mass with the metallic plates, sometimes in contact with the poles of a voltaic battery, and sometimes even with the electric machine, for the advantage of the much higher intensity then obtained, I passed a polarized ray across it in various directions, as before, but could not obtain the slightest appearance of action upon the light. Hence I conclude, that notwithstanding the new and extraordinary state which must be assumed by an electrolyte, either during decomposition (when a most enormous quantity of electricity must be traversing it), or in the state of tension which is assumed as preceding decomposition, and which might be supposed to be retained in the solid form of the electrolyte, still it has no power of affecting a polarized ray of light; for no kind of structure or tension can in this way be rendered evident.

956. There is, however, one beautiful experimental proof of a state of tension acquired by the metals and the electrolyte before the electric current is produced, and *before contact* of the different metals is made (915.); in fact, at that moment when chemical forces only are efficient as a cause of action. I took a voltaic apparatus, consisting of a single pair of large plates, namely, a cylinder of amalgamated zinc, and a double cylinder of copper. These were put into a jar containing dilute sulphuric acid *, and could at pleasure be placed in metallic communication by a copper wire adjusted so as to dip at the extremities into two cups of mercury connected with the two plates.

957. Being thus arranged, there was no chemical action whilst the plates were not connected. On *making* the connexion, a spark was obtained †, and the solution was immediately decomposed. On breaking it, the usual spark was obtained, and the decomposition ceased. In this case it is evident that the first spark must have occurred before metallic contact was made, for it passed through an interval of air, and also that it must have tended to pass before the electrolytic action began; for the latter could not take place until the current passed, and the current could not pass before the spark appeared. Hence I think there is sufficient proof, that as it is the zinc and water which by their mutual action produce the electricity of this apparatus, so these, by their first contact with each other, were placed in a state of powerful tension (951.), which, though it could not produce the actual decomposition of the water, was able to make a spark of electricity pass between the zinc and a fit discharger as soon as the interval was rendered sufficiently small. The experiment demonstrates the direct production of the electric spark from pure chemical forces.

958. There are a few circumstances connected with the production of this spark by a single pair of plates, which should be known, to ensure success to the experiment. When the amalgamated surfaces of contact are quite clean and dry, the spark, on making contact, is quite as brilliant as on breaking it, if not even more so. When a film of oxide or

* When nitro-sulphuric acid is used, the spark is more powerful, but local chemical action can then commence, and proceed without requiring metallic contact.

† It has been universally supposed that no spark is produced on making the contact between a single pair of plates. I was led to expect one from the considerations already advanced in this paper. The wire of communication should be short; for with a long wire, circumstances strongly affecting the spark are introduced.

dirt was present at either mercurial surface, then the first spark was often feeble, and often failed, the breaking spark, however, continuing very constant and bright. When a little water was put over the mercury, the spark was greatly diminished in brilliancy, but very regular both on making and breaking contact. When the contact was made between clean platina, the spark was also very small, but regular both ways. The true electric spark is, in fact, very small, and when surfaces of mercury are used, it is the combustion of the metal which produces the greater part of the light. The circumstances connected with the burning of the mercury are most favourable on breaking contact; for the act of separation exposes clean surfaces of metal, whereas, on making contact, a thin film of oxide, or soiling matter, often interferes. Hence the origin of the general opinion that it is only when the contact is broken that the spark passes.

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959. With reference to the other set of cases, namely, those in which chemical affinity is exerted (947.), but where no transference of the power to a distance takes place, and where no electric current is produced, it is evident that forces of the most intense kind must be active, and in some way balanced in their activity, during such combinations; these forces being directed so immediately and exclusively towards each other, that no signs of the powerful electric current they can produce become apparent, although the same final state of things is obtained as if that current had passed. It was Berzelius, I believe, who considered the heat and light evolved in cases of combustion as the consequences of this mode of exertion of the electric powers of the combining particles. But it will require a much more exact and extensive knowledge of the nature of electricity, and the manner in which it is associated with the atoms of matter, before we can understand accurately the action of this power in thus causing their union, or comprehend the nature of the great difference which it presents in the two modes of action just distinguished. We may imagine, but such imaginations must for the time be classed with the great mass of *doubtful knowledge* (876.) which we ought rather to strive to diminish than to increase; for the very extensive contradictions of this knowledge of itself shows that but a small portion of it can ultimately prove true.

960. Of the two modes of action in which chemical affinity is exerted, it is important to remark, that that which produces the electric current is as *definite* as that which causes ordinary chemical combination; so that in examining the *production* or *evolution* of electricity in cases of combination or

decomposition, it will be necessary, not merely to observe certain effects dependent upon a current of electricity, but also their *quantity*: and though it may often happen that the forces concerned in any particular case of chemical action may be partly exerted in one mode and partly in the other, it is only those which are efficient in producing the current that have any relation to voltaic action. Thus, in the combination of oxygen and hydrogen to produce water, electric powers to a most enormous amount are for the time active (861. 873.); but any mode of examining the flame which they form during energetic combination, which has as yet been devised, has given but the feeblest traces. These therefore may not, cannot, be taken as evidences of the nature of the action; but are merely incidental results, incomparably small in relation to the forces concerned, and supplying no information of the way in which the particles are active on each other, or in which their forces are finally arranged.

961. That such cases of chemical action produce no *current of electricity*, is perfectly consistent with what we know of the voltaic apparatus, in which it is essential that one of the combining elements shall form part of, or be in direct relation with, an electrolytic conductor (921. 923.). That such cases produce no *free electricity of tension*, and that when they are converted into cases of voltaic action they produce a current in which the opposite forces are so equal as to neutralize each other, prove the equality of the forces in the opposed acting particles of matter, and therefore the equality of electric power in those quantities of matter which are called *electro-chemical equivalents* (824.). Hence another proof of the definite nature of electro-chemical action (783. &c.), and that chemical affinity and electricity are forms of the same power (917. &c.).

962. The direct reference of the effects produced by the voltaic pile at the place of experimental decomposition to the chemical affinities active at the place of excitation (891. 917.), gives a very simple and natural view of the cause why the bodies or *ions* evolved pass in certain directions; for it is only when they pass in those directions that their forces can consist with and compensate (in direction at least) the superior forces which are dominant at the place where the action of the whole is determined. If, for instance, in a voltaic circuit, the activity of which is determined by the attraction of zinc for the oxygen of water, the zinc move from right to left, then any other *cation* included in the circuit, being part of an electrolyte, or forming part of it at the moment, will also move from right to left; and as the oxygen of the water, by

its natural affinity for the zinc, moves from left to right, so any other body of the same class with it (*i. e.* any other *anion*), and under its government for the time, will move from left to right.

963. This I may illustrate by reference to fig. 11, the double circle of which may represent a complete voltaic circuit, the direction of its forces being determined by supposing for a moment the zinc *b* and the platina *c* as representing plates of those metals acting upon water, *d*, *e*, and other substances, but having their energy exalted so as to effect several decompositions by the use of a battery at *a* (989.). This supposition may be allowed, because the action in the battery will only consist of repetitions of what would take place between *b* and *c*, if they really constituted but a single pair. The zinc *b*, and the oxygen *d*, by their mutual affinity, tend to unite; but as the oxygen is already in association with the hydrogen *e*, and has its inherent chemical or electric powers neutralized for the time by those of the latter, the hydrogen *e* must leave the oxygen *d*, and advance in the direction of the arrow head, or else the zinc *b* cannot move in the same direction to unite to the oxygen *d*, nor the oxygen *d* move in the contrary direction to unite to the zinc *b*, the relation of the *similar* forces of *b* and *e*, in contrary directions, to the *opposite* forces of *d* being the preventive. As the hydrogen *e* advances, it, on coming against the platina *c*, *f*, which forms a part of the circuit, communicates its electric or chemical forces through it to the next electrolyte in the circuit, fused chloride of lead, *g*, *h*, where the chlorine must move in conformity with the direction of the oxygen at *d*, for it has to compensate the forces disturbed in its part of the circuit by the superior influence of those between the oxygen and zinc at *d*, *b*, aided as they are by those of the battery *a*; and for a similar reason the lead must move in the direction pointed out by the arrow head, that it may be in right relation to the first moving body of its own class, namely, the zinc *b*. If copper intervene in the circuit from *i* to *k* it acts as the platina did before; and if another electrolyte, as the iodide of tin, occur at *l*, *m*, then the iodine *l*, being an *anion*, must move in conformity with the exciting *anion*, namely, the oxygen *d*, and the *cation* tin *m* move in correspondence with the other *cations* *b*, *e*, and *h*, that the chemical forces may be in equilibrium as to their direction and quantity throughout the circuit. Should it so happen that the anions in their circulation can combine with the metals at the *anodes* of the respective electrolytes, as would be the case at the platina *f* and the

copper *k*, then those bodies becoming parts of electrolytes, under the influence of the current, immediately travel; but considering their relation to the zinc *b*, it is evidently impossible that they can travel in any other direction than what will accord with its course, and therefore can never tend to pass otherwise than *from* the anode and *to* the cathode.

964. In such a circle as that delineated, therefore, all the known *anions* may be grouped within, and all the *cations* without. If any number of them enter as *ions* into the constitution of *electrolytes*, and, forming one circuit, are simultaneously subject to one common current, the anions must move in accordance with each other in one direction, and the cations in the other. Nay, more than that, equivalent portions of these bodies must so advance in opposite directions; for the advance of every 32·5 parts of the zinc *b* must be accompanied by a motion in the opposite direction of 8 parts of oxygen at *d*, of 36 parts of chlorine at *g*, of 126 parts of iodine at *l*; and in the same direction by electro-chemical equivalents of hydrogen, lead, copper and tin, at *e*, *h*, *k*, and *m*.

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965. If the present paper be accepted as a correct expression of facts, it will still only prove a confirmation of certain general views put forth by Sir Humphry Davy in his Bakerian Lecture for 1806*, and revised and re-stated by him in another Bakerian Lecture, on electrical and chemical changes, for the year 1826†. His general statement is, that "*chemical and electrical attractions were produced by the same cause, acting in one case on particles, in the other on masses, of matter; and that the same property, under different modifications, was the cause of all the phænomena exhibited by different voltaic combinations*‡." This statement I believe to be true; but in admitting and supporting it, I must guard myself from being supposed to assent to all that is associated with it in the two papers referred to, or as admitting the experiments which are there quoted as decided proofs of the truth of the principle. Had I thought them so, there would have been no occasion for this investigation. It may be supposed by some that I ought to go through these papers, distinguishing what I admit from what I reject, and giving good experimental or philosophical reasons for the judgement in both cases. But then I should be equally bound to review, for the same purpose, all that has been written both for and

* Philosophical Transactions, 1807.

† *Ibid.* 1826, p. 383. [or Phil. Mag. and Annals, N.S., vol. i. p. 31.]

‡ *Ibid.* 1826, p. 389. [Phil. Mag. and Annals, N.S., vol. i. p. 36.]

against the necessity of metallic contact,—for and against the origin of voltaic electricity in chemical action,—a duty which I may not undertake in the present paper*.

[To be continued.]

XXX. *Formula for inferring the Dew-point from the Indications of the Wet-bulb Hygrometer. By* JAMES APJOHN, *M.D., Professor of Chemistry in the Royal College of Surgeons, Ireland.*

To the Editors of the Philosophical Magazine and Journal.

Gentlemen,

WILL you allow me to give publicity, through your valuable Journal, to the following formula for inferring the dew-point from the indications of the wet-bulb hygrometer? It formed the subject of a paper read by me in November last before the Royal Irish Academy, and which will appear in their Transactions. As, however, the next number of these will not be published for some months, I am permitted by the Council of the Academy to present the substance of my communication to the world through the medium of one of the scientific periodicals. I shall not enter here into any historical or critical remarks upon the attempts made by Leslie, Anderson, and others, to elucidate the same subject, for the methods of all are known to be imperfect; and of this no better proof can be given than that the theory of the moist-bulb hygrometer is found among the questions submitted by the first meeting of the British Association held at York to the renewed consideration of philosophers. For the present I shall confine myself to an explanation of the method of investigation which I myself pursued, and of the results to which it led.

When in the moist-bulb hygrometer the stationary temperature is attained, the caloric which vaporizes the water is necessarily exactly equal to that which the air imparts in descending from the temperature of the atmosphere to that of the moistened bulb. The air, also, which has undergone this

* I at one time intended to introduce here, in the form of a note, a table of reference to the papers of the different philosophers who have referred the origin of the electricity in the voltaic pile to contact, or to chemical action, or to both; but on the publication of the first volume of M. Becquerel's highly important and valuable *Traité de l'Electricité et du Magnétism*, I thought it far better to refer to that work for these references, and the views held by the authors quoted. See pages 86, 91, 104, 110, 112, 117, 118, 120, 151, 152, 224, 227, 228, 232, 233, 252, 255, 257, 258, 290, &c.—July 3rd, 1834.

reduction becomes saturated with moisture. Now, from these facts, and the known specific heat of air, we can calculate the weight of water m' which would be converted into vapour by the heat which a given weight of air would evolve in cooling from t, the temperature of the atmosphere, to t', that of the moistened bulb; and we can also calculate the total quantity of moisture m which the same weight of air would contain at t', if saturated. This being accomplished, if f' be the tension of vapour at the temperature t', $\left(1-\frac{m'}{m}\right) f' = f''$, the tension of vapour at t'', the dew-point. This expression is strictly correct, for it is obviously deduced from the fact of the tension of vapour at a given temperature and under a given volume being proportional to its quantity or specific gravity.

A convenient value of $\left(1-\frac{m'}{m}\right) f'$ may be found in the following manner. Unity representing the specific heat of water, ·267 (Delaroche and Berard) is that of air. Also 967° being the caloric of elasticity of steam at 212°, $212-50+967 = 1129°$ will be its caloric of elasticity at 50°, assuming, as is generally done, that the sum of the sensible and latent heats of vapour is the same at every temperature. One grain of air, therefore, in cooling through any number of degrees d, will raise the temperature of ·267 grains of water through the same number, and will consequently be adequate to vaporize a quantity of water represented by $\frac{\cdot 267\, d}{1129} = \frac{d}{4195}$ grains; or, multiplying by the denominator, 4195 grains of water in cooling through d degrees give out the exact quantity of heat which constitutes the caloric of elasticity of d grains of vapour. But the volume of this weight of air at 60°, and under a pressure of 30, is 13754 cubic inches; and at the temperature t', and pressure p, $13754 \times \frac{448+t'}{508} \times \frac{30}{p} = 27 \times \overline{448+t'}$ $\times \frac{30}{p}$ cubic inches. Hence

$$\left(27 \times \overline{448 t'} \times \frac{30}{p}\right) \times \left(10{\cdot}583 \times \frac{f'}{448+t'} \times {\cdot}305^*\right) = 87 \times \frac{30}{p}$$

$\times f' =$ the quantity of moisture which the air contains

* $10{\cdot}583 \times \frac{f'}{448+t'} \times {\cdot}305 =$ weight of a cubic inch of vapour whose tension is f' and temperature t'.

when saturated at t'. We will therefore have, on the principle already explained, $\left(1 - \frac{d}{37 \times \frac{30}{p} \times f'}\right) \times f' = f' - \frac{p\,d}{30 \times 37}$ $= f''$, the tension of vapour at the dew-point. If $p = 30$, $f'' = f' - \frac{d}{87}$.

To this solution the following objections may be urged:

1st, That the air which is cooled by contact with the moistened bulb at its stationary temperature is assumed without proof to be saturated with moisture.

2nd, That the caloric of elasticity of steam is 1129° only at 50°.

3rd, That the specific heat of air is ·267 only under a pressure of 30.

4th, That the medium which is cooled from t to t' is not pure air, but a mixed atmosphere of air and vapour.

5th, That the caloric which, at the temperature t', converts the water into vapour, is not derived exclusively from the air by contact, but partly also by radiation from surrounding bodies.

With respect to the first objection, I have only to observe that air, if not an absolute non-conductor, is at least a very bad conductor of heat, and that it is, therefore, very unlikely that the reduction of temperature which it experiences in the experiment in question can be effected in any other way than by actual contact with the moistened bulb. But if such contact be established in the case of every indefinitely thin aërial shell, there can, I conceive, be no doubt that each becomes charged with the full amount of moisture which belongs to its reduced temperature.

In reference to the second objection it must, of course, be admitted that the caloric of elasticity of vapour varies with its temperature, and that it is represented by the number 1129 only at 50°, a point chosen because of its being nearly the mean temperature of Dublin. In strictness, the number employed should be $967 + 212 - t'$, but it would be easy to show that the uniform use of 1129 cannot give rise to any material error.

The third objection is one of considerable weight. The specific heat of air varies with the pressure, and in order to secure accuracy of result, a proper correction must undoubtedly be made for this variation. But what is the law which this latter observes? Upon this point different opinions would appear to be entertained. According, however, to Delaroche and

Berard, (whose views, if not rigorously exact, are sufficiently so for my present purpose,) for small variations of pressure, such as occur to the natural atmosphere, the differences of specific heats under a constant volume are proportional to the differences of pressure. And the same philosophers have shown that for pressures in the ratio of 1 to 1·3583, the corresponding capacities are 1 and 1·2396. Hence, as

$\cdot 3583 : \cdot 2396 :: \frac{p}{30} - 1 : \frac{x}{c} - 1$, c being the specific heat

under a constant volume at 30, and x that at p; a proportion from which we deduce $x = (\cdot 0223\, p + \cdot 3312)\, c$.

But the specific heats under a constant volume, divided by the densities, give the specific heats of equal weights. And as the densities vary as the pressures directly, and as the temperatures $+448$ inversely, and are therefore to each other

in the present case as $\frac{30}{508}$ to $\frac{p}{448+t'}$, we shall have

$$\frac{503}{30} \times c : (\cdot 0223\, p + \cdot 3312)\, c \times \frac{448+t'}{p} :: \cdot 267 : x';$$

so that x', or the specific heat of air at temperature t' and

pressure $p = \frac{448+t'}{508} \times \frac{30}{p} \times (\cdot 0223\, p + \cdot 3312) \times \cdot 267$.

The value, therefore, of f'' already given, when corrected for the influence of pressure on specific heat, will become

$f' - \frac{d}{87} \times \frac{448+t'}{508} \times (\cdot 0223\, p + \cdot 3312)$; an expression which

is obviously, as it ought, reduced to $f' - \frac{d}{87}$ when $t' = 60°$,

and $p = 30$.

The theoretical justness of the fourth objection must also be conceded. The medium which is in contact with the bulb of the hygrometer is not dry air, but air charged with the amount of vapour which belongs to the existing dew-point; and, as the specific heats of air and vapour are different, this mixed atmosphere in cooling through $t - t'$ degrees will evidently not give out the same quantity of caloric, and can therefore not convert into vapour the same quantity of water that would be evolved and vaporized by the same weight of dry air alone. In fact, for ·267 the specific heat of air, we should in strictness substitute the specific heat of the mixture of air and vapour; or, what will answer the same purpose,

multiply by the ratio of these the subtractive terms in the value of f'' already obtained.

To determine the specific heat of a mixture, the simple rule is to multiply the relative weights of its constituents by their respective capacities, and to divide the sum of the products by the sum of the weights. But in the present instance the weights, being obviously as the specific gravities, are to each other as $1 : \cdot 625 \frac{f''}{p}$. Also the specific heat of air being $\cdot 267$, and that of vapour $\cdot 847$, the former is to the latter as $1 : 3\cdot 172$. Hence, according to the rule given above, we shall have $\frac{1 + \cdot 625 \frac{f''}{p} \times 3\cdot 172}{1 + \cdot 625 \frac{f''}{p}}$ for the specific heat of the mixture of air and vapour referred to that of dry air taken as unity; and, applying the correction as already explained, we shall have an equation in which f'' is the only unknown quantity, and from which, therefore, its value may be found. This equation, however, being a quadratic, and the unknown quantity in its first elimination having a coefficient of three terms, its solution would involve tedious arithmetical operations, and cannot, therefore, be recommended to the practical meteorologist as a means of making the correction in question. Nor is this course at all necessary; for the same object may be achieved, according to a simpler, though less rigorous method, by either assigning to f'' an average value, or by deducing approximately the tension of vapour at the dew-point by the formula

$$f'' = f' - \frac{d}{87} \times \frac{448 + t'}{508} \times (\cdot 0223\, p + \cdot 3312),$$

and using the value of f'' thus obtained, in order to determine that of $\frac{1 + \cdot 625 \frac{f}{p} \times 3\cdot 172}{1 + \cdot 625 \frac{f}{p}}$, the specific heat of the mixture of air and vapour. The latter method is decidedly the best, and though not mathematically accurate, will not, I believe, exhibit a deviation from the truth until the calculation be pushed to the seventh or eighth decimal place.

I have now to notice the last circumstance which, as far as I understand the subject, can have any influence upon the accuracy of my determination of the dew-point.

When the wet-bulb hygrometer has attained its stationary

temperature, the quantities of caloric which it loses and gains in a given time are perfectly equal. This requires no demonstration. The caloric lost also is entirely employed in converting the water into vapour; but the whole of the acquired caloric is not necessarily derived, though this is assumed to be the case, from the air cooled by contact with the bulb of the instrument. In fact, the hygrometer is in the predicament of a cool body placed in a warm medium, and it must consequently receive from surrounding bodies by radiation a greater amount of caloric than it imparts to them in virtue of the same process. To the d grains, therefore, of moisture converted into vapour by the heat given out by 4195 grains of air in cooling through d degrees, we should add the additional quantity vaporized by the heat which the bulb has in the same time received by radiation. Where $t-t'$ is small, this quantity may probably be safely neglected, but it will sometimes, I make no doubt, be of sufficient magnitude to exert an appreciable influence. I regret my inability to assign any means of determining its amount, and shall merely add that the neglect of this correction will always tend to make the calculated dew-point somewhat higher than the true.

Having disposed thus rapidly of the theory of my method, I shall conclude by subjecting the results which it affords to the test of experiment: I shall not at present refer to my own observations, though I have amassed a considerable number on the hygrometer and dew-point. As a more unimpeachable criterion I shall compare my formula with the observations of others, and shall select for this purpose, it being the nearest to hand, a table published in the last number [Oct. 1834] of Prof. Jameson's Edinburgh New Philosophical Journal. The differences, it will be seen, between the corresponding numbers of the fourth and fifth* columns, are so small that we may consider them as almost entirely due to errors of observation. I may add, that as in the original table there is no notice taken of the barometer, the formula in its most complete form could not be applied, so that a perfect coincidence between calculation and observation was not in this instance to be expected.

January 3, 1835. JAMES APJOHN.

* The numbers in the fourth column are the observed dew-points, and those in the fifth the dew-points deduced by my formula.

	t	t'	t'' Observed.	t'' Calculated.
1	68·25	61·75	57·25	57·5
2	56·25	54·5	53·25	53·
3	64·5	59·	54·5	55·
4	67·5	61·25	55·75	57·
5	67·25	61·	56·75	56·75
6	63·	59·	56·25	56·20
7	62·25	57·75	55·25	54·4
8	68·	61·75	57·25	57·2
9	63·25	59·	56·5	56·
10	69·5	63·	58·25	58·75
11	68·75	61·	56·25	55·66
12	63·5	58·	54·75	53·8
13	63·75	58·	54·5	53·6
14	68·	61·25	56·25	56·6
15	65·5	59·75	55·25	57·4
16	69·	62·	57·25	57·3
17	66·5	61·	57·5	57·5
18	66·25	61·	57·5	54·
19	67·	59·5	54·5	54·5
20	64·5	58·75	54·25	54·4
21	64·75	58·75	53·75	49·9
22	59·	54·50	50·	53·1
23	63·75	57·75	53·75	52·5
24	63·5	57·25	52·25	50·5
25	59·75	54·75	49·25	51·25
26	62·5	56·25	51·25	52·75
27	61·25	56·5	53·25	53·25
28	60·75	56.5	53·25	54·
29	62·75	57·75	53·75	57·1
30	65·5	60·5	55·75	58·5
31	64·75	61·	58·25	53·25
32	61·25	57·25	49·75	52·5
33	62·5	57·25	52·75	53·5
34	62·25	56·75	52·75	50·33
35	60·25	56·5	53·75	50·33
36	57·25	53·75	51·5	50·25
37	...	...	51·	53·66
38	58·5	54·	50·75	59·

XXXI. *An Abstract of the essential Principles of* M. Cauchy's *View of the Undulatory Theory, leading to an Explanation of the Dispersion of Light; with Remarks. By the Rev.* Baden Powell, *M.A., F.R.S., Savilian Professor of Geometry, Oxford.*

[Continued from p. 113.]

IN the motions expressed by equation (40.), we may observe that the displacements and velocities depend on the sole variables ϱ and t; and at the end of the time t, therefore, they are the same for all molecules situated at the same distance ϱ from the plane (16.) to which it is perpendicular.

We have thus far obtained expressions for $\xi\,\eta\,\zeta$, the resolved parts of the actual displacement of a molecule m in the directions of three rectangular axes in terms of $s'\,s''\,s'''$, which represent three distinct absolute motions or displacements in the directions of three lines at right angles in space, determined by the circumstance of their coinciding with the axes of a given ellipsoid, and having determinate inclinations to a given plane dependent on the values of the arbitrary quantities which enter into the expressions. We have also general expressions for the velocities in those directions; and in general some of the molecules may take each one of the three motions thus defined.

Now, if at the commencement of the motion the displacement of all the molecules take place in directions parallel to one of the three axes of the ellipsoid just referred to, and the whole velocities are consequently to be estimated in those lines, then the initial values, or the functions $\varpi(\varrho)$ $\Pi(\varrho)$ expressed by equations (36.) and (37.), will vanish for two of the values of s. And consequently for any time t, the displacement s determined by equation (40.) will also vanish for the same two values of s: or, in other words, two of the displacements of the molecules will likewise always vanish, or the whole motion will continue always parallel to the same axis of the ellipsoid. We will take s as that one value which does not vanish. Except so far as the remark above made extends, viz. that the motions are the same at the same time for all molecules situated at the same distance from the plane (16.), the expression above given for the value s (40.) is not of such a nature that we can *directly* infer from it the actual conditions of the sort of displacement which a molecule undergoes, or the consequences which result; but we may arrive at some conclusions of this kind if we can suppose the

functions to be subject to a particular condition, viz. that we may have a function $\varpi'(\varrho)$, such as to give

$$\Pi(\varrho) = \Omega\,\varpi'(\varrho); \tag{42.}$$

in which case it will be found that the expression (40.) will be reducible to

$$8 = \varpi(\varrho + \Omega t). \tag{43.}$$

Now, from this form it follows that if ϱ and t receive the respective increments $\Delta\varrho$ and Δt, the value of 8 will remain the same, if we have

$$\Delta\varrho = -\Omega\,\Delta t; \tag{44.}$$

that is, the displacement 8 will be the same for a molecule situated at the end of the time t, at the distance ϱ, from the plane (16.), and for a molecule situated at the end of the time $t + \Delta t$ at the distance $\varrho + \Delta\varrho$.

The motion, then, of a molecule m is immediately transmitted to other molecules situated on the side on which the values of ϱ are *negative*; and the velocity with which the motion is propagated in the direction perpendicular to the plane (16.), which is expressed by the value of $\frac{\Delta\varrho}{\Delta t}$ given by equation (19.), will be exactly equal to the *positive* constant Ω.

Again, it is evident, from the form of the functions (36.) (37.), that they have the same *recurring values* when we suppose ϱ to increase by $\frac{2\pi}{k}$, and consequently the function (43.) will do the same when ϱ is thus increased, and t by $\frac{2\pi}{k\Omega}$. Let us assume

$$l = \frac{2\pi}{k} \quad (45.), \qquad \text{and} \qquad \mathrm{T} = \frac{2\pi}{k\Omega} \quad (46.)$$

If now, at the end of the time t, we divide the space into an indefinite number of laminæ by parallel planes corresponding to the values of ϱ which reproduce the periodical equal values of 8 or of $\frac{d8}{dt}$, then it will evidently represent the thickness of each lamina, while T represents the time of the isochronous oscillations performed successively by a molecule. We will call these laminæ "plane waves," and we will suppose their thicknesses divided into two equal parts by that one of the parallel planes whose equation is

$$ax + by + cz = \varrho = -\Omega t. \tag{47.}$$

Then for the points through which these planes pass, we shall have constantly

$$s = \varpi(0), \quad \text{and} \quad \frac{ds}{dt} = \Omega \varpi'(0); \tag{48.}$$

or, what is the same thing, from (36.) (37.),

$$s = d_0 A + e_0 B + f_0 C \text{ and } \frac{ds}{dt} = k\Omega(g_0 A + h_0 B + i_0 C) \tag{49.}$$

And for the planes bounding the waves successively,

$$s = \varpi\left(\frac{l}{2}\right) \quad \frac{ds}{dt} = k\Omega\varpi'\left(\frac{l}{2}\right); \tag{50.}$$

or, what is the same thing,

$$s = -[d_0 A + e_0 B + f_0 C]$$

and

$$\frac{ds}{dt} = -k\Omega(g_0 A + h_0 B + i_0 C] \tag{51.}$$

Further, the velocity of the propagation of a plane wave, or, in other words, the velocity of the displacement of the plane (47.) measured perpendicular to it, will be *constant* by virtue of the formula (47.), and represented by Ω.

If we suppose the functions such as to fulfill the same conditions as those of (42.) with only the difference of the sign, or

$$\Pi(\varrho) = -\Omega\varpi'(\varrho), \tag{52.}$$

the same considerations readily show that we should have

$$s = \varpi(\varrho - \Omega t), \tag{53.}$$

and by consequence, in the same way as before,

$$\Delta\rho = \Omega\Delta t. \tag{54.}$$

The inference, then, will here be that the motion of m is immediately transmitted to molecules on the *positive* side, the velocity being still the positive constant Ω.

It may also be observed in either case, that the formula which determines s in functions of k for a given direction of the plane (16.), will also determine T or Ω in functions of l.

If, however, the functions $\Pi(\varrho)$ and $\varpi(\varrho)$ be such that the condition (42.) is not fulfilled either with the positive or negative sign, then we cannot proceed to determine the value of s by the conditions involved in the former investigation; that is, it will follow that the formula (39.), or the three similar formulas involving the three values of s, will not enable us to determine the nature and conditions of the three displacements in directions parallel to the axes of the ellipsoid. But we may consider the value of s as representing a motion produced by the composition of six motions (three on each side of the given plane), each corresponding to that represented by the equations (43.) and (53.), according to their signs.

The plane waves corresponding to each of these six mo-

tions will propagate themselves in space with velocities equal, two and two, but proceeding in opposite directions, and represented by Ω', Ω'', Ω'''.

We have already observed that from the form of the functions (36. 37.), $\mathfrak{s}_0$ and $\mathfrak{s}_1$ have recurring values when ϱ is increased by $\frac{2\pi}{k}$; and the similar remark made with respect to the function (43.), it will also be seen, is not restricted to that particular case, but applies equally to the general formula (38.), when t is increased by $\frac{2\pi}{k\Omega}$. Thus, then, adopting the notation of (45. 46.) for the intervals of recurrence in space and in time, we have directly from those expressions

$$\Omega = \frac{l}{\mathrm{T}} \qquad (55.)$$

Or we find in general that there is always a constant relation between the *length of a wave* and the velocity of its propagation; or, in other words, that the velocity of the propagation is directly as the lengths of the waves, and inversely as the times of the oscillations of the individual molecules of the ætherial fluid; or, what is the same thing, the interval of the time of the recurrence or arrival of two successive waves at the same point.

It must be recollected that, in order to simplify the investigation, we have proceeded solely with reference to a single displacement in the direction of each of the axes; or, more precisely, it has been conducted on the assumption made at first, that we might consider each of the expressions (17.) as reduced to a single term: those expressions, however, really involve the sum of a number of similar terms. In the expressions (23.), therefore, which represent the initial values of $\xi\ \eta\ \zeta$ and of their differentials, as well as in the equations (33.), the same consideration must be attended to, that is, we must take

$$\xi_0 = \Sigma\,[\mathrm{d}_0 \cos k\,\varrho + \mathrm{g}_0 \sin k\,\varrho] \qquad (56.)$$
&c.

$$\xi_1 = \Sigma\,[\mathrm{d}_1 \cos k\,\varrho + \mathrm{g}_1 \sin k\,\varrho] \qquad (57.)$$
&c.

$$\xi\ = \Sigma\,[\mathrm{A}'\,\mathfrak{s}' + \mathrm{A}''\,\mathfrak{s}'' + \mathrm{A}'''\,\mathfrak{s}'''] \qquad (58.)$$
&c.

We shall then have only to introduce the values of $\mathfrak{s}'\ \mathfrak{s}''\ \mathfrak{s}'''$ as above found, and the motion of the system may be considered as produced by the combination of many, or even an infinity of similar motions, each the same as those represented by the equations (43.) and (53.).

Finally, in order to complete the analytical view of the sub-

ject, M. Cauchy proceeds to show how the sum of terms indicated by Σ may be changed into definite integrals. In this investigation it will not be necessary to our purpose to follow him, but we shall proceed to some remarks on the expressions above deduced and their physical applications.

[To be continued.]

XXXII. *Œconomical Means of procuring pure the Salts of Manganese, and of analysing the Minerals which contain Manganese and Iron, &c. By* THOMAS EVERITT, *Esq., Professor of Chemistry to the Medico-Botanical Society, &c.**

HAVING had occasion for some pounds of pure salts of manganese for experiments on dyeing, my attention was turned to consider the convenience and œconomy of those processes prescribed in our systematic works. The process of Faraday by hydrochlorate of ammonia, is easy of execution, and perfect as to the results, but expensive; that of Turner, "by mixing the oxide left after procuring oxygen gas by heat with one sixth of charcoal, and exposing to a white heat for half an hour in a covered crucible, dissolving in hydrochloric acid, evaporating to dryness, and keeping the mass in perfect fusion for a quarter of an hour, &c." yields also good results, but is tedious in the execution, and expensive, if time and trouble be considered; moreover, by the first ignition, although we subsequently save a little hydrochloric acid (none being lost as chlorine) by reducing the manganese to protoxide, we also at the same time render the iron in such a state that on dissolving in hydrochloric acid, we have a protoxide, which is more difficult to get quit of by the second ignition than it would have been as a peroxide.

As I possessed a large quantity of hydrochlorate of manganese and iron, the accumulated solutions from preparing chlorine by hydrochloric acid and ordinary oxide of manganese, I was induced to make a variety of trials on this liquid with the view of separating the iron from the manganese; the results of which trials being entirely satisfactory, I venture to request a place for a short account of them in the London and Edinburgh Philosophical Magazine.

Method, No. I.—*Depending on the circumstance that when a solution of hydrochlorate of iron, strictly peroxide (which is always the case in the above liquid), is evaporated to dryness, and the heat afterwards slightly elevated, a small portion sub-*

* Communicated by the Author.

limes as perchloride: the rest is decomposed into free hydrochloric acid and peroxide, which remains behind.

The clear decanted or filtered liquid, generally acid and of a dark colour, is to be evaporated to dryness in a porcelain dish, when a mass of small bright yellow crystals will be obtained. The heat of the sand-bath is now to be considerably increased, when, by constantly stirring the mass, taking care to heat the sides as well as the bottom of the dish, it soon acquires a gray ashy aspect; and if the operation be continued till hydrochloric acid gas ceases to rise (this to be ascertained by holding a rod dipped in ammonia over it), we obtain, on pouring water on it and filtering, a colourless liquid, containing all the hydrochlorate of manganese and no iron, since it will be found to give a white precipitate with yellow ferro-prussiate of potassa, having no blue tinge. This latter part of the process may be conducted with much greater dispatch by putting the dry yellow salt into an ordinary iron ladle, and stirring with an iron rod over a slow fire till it becomes ash-gray, or till all hydrochloric acid fumes cease to rise. The heat never requires to be raised near redness so as to fuse the mass; for small quantities this part of the operation may be performed in a platina crucible.

Having a pure hydrochlorate, of course all the other salts can be obtained: the carbonate by precipitation with carbonate of soda, filtering, washing, &c., and from it any salt or preparation required by the scientific chemist.

Should the manganese ore have originally contained barytes or lime, these must be removed from the solution before precipitating the carbonate of manganese, the first by a little sulphate of soda, the second by a little oxalate of ammonia: this, however, does not remove the last traces of lime—(*according to Turner*).

Method, No. 2.—*Depending on the circumstance that carbonate of manganese will precipitate peroxide of iron when boiled in a solution of any peroxide salt of this metal.*

Add to the filtered solution of hydrochlorate of peroxide of iron and manganese, a small quantity of carbonate of soda, so as to precipitate a small portion only of peroxide of iron and carbonate of manganese: now boil for five or ten minutes, when the carbonate of manganese will be redissolved, throwing down and replacing the peroxide of iron. If, on filtering a minute quantity of the solution, some iron is still found to be present, by its yielding with yellow ferro-prussiate of potassa a precipitate tinged with blue, a little more carbonate of soda is to be added, and the liquid boiled again: a very little experience will enable the operator by this means to free the solution entirely from iron, and at the same time to

have a very small portion of carbonate of manganese remaining with the precipitated peroxide of iron. The filtered solution will now contain nothing but hydrochlorate of soda and hydrochlorate of manganese, and from it the pure carbonate of manganese may be obtained as before.

A slight modification of this process may be made if we require at once a pure hydrochlorate of manganese free from all salts of soda or potassa. Add to the compound solution, freed from excess of acid by partial evaporation and resolution, some carbonate of manganese, enough to replace the peroxide of iron; boil for some time, filter, &c.: or, if the operator have no carbonate of manganese, take a portion of the liquid apart, precipitate by carbonate of soda all the iron and manganese, and wash well; then remove the still wet mass from the filter, consisting of carbonate of manganese and peroxide of iron, add this to the remaining liquid and boil, when, as before, the rest of the iron will be precipitated and replaced by the manganese. Of course the portion of liquid which must be precipitated apart depends upon the relative quantities of iron and manganese in the solution, and on the quantity of free acid: in my experiments $\frac{1}{20}$ of the solution was sufficient to furnish enough of the precipitate to effect the entire purification of the remaining $\frac{19}{20}$; but I had removed nearly all excess of acid by evaporation.

This process is peculiarly adapted to the purification of a solution of hydrochlorate of manganese containing only a trace of iron, saving thereby the trouble of evaporating the whole of the liquid and igniting: thus, I found in one of my trials that I had four pints of a strong solution of hydrochlorate of manganese containing only a trace of iron; the evaporation of all this to dryness and igniting would (seeing it contained more than a pound of hydrochlorate of manganese,) have been a very long and tedious operation, but by adding a few grains of carbonate of manganese, and boiling for a quarter of an hour, it became quite pure.

It must be borne in mind that the success of these methods depends entirely on the iron being strictly peroxide: should any protoxide be present, this must be peroxidized by the addition of nitric acid.

I find that carbonate of manganese free from iron can also be procured from the liquid obtained, on dissolving the mass left after procuring chlorine by common salt, oxide of manganese, and sulphuric acid,—by the method, No. 2.

Hence, the dyer, potter, or glass-maker can now have, at a trifling expense, all the preparations of manganese chemically pure; and the absence of iron is of much importance in many of their applications in the arts, a subject which has for some

time been the object of my experiments, and for an account of some of the results of which I may at a future day beg a place in this Journal.

The second part of this paper, containing the application of the above principles to the analysis of minerals containing manganese and iron, and an examination of those methods now used, will appear in a future Number.

28, Golden Square, London, December 12, 1834.

XXXIII. *Analytical Theorems relating to Geometrical Series.* *By* Charles Blackburn, *A.B.*

To the Editors of the Philosophical Magazine and Journal.

Gentlemen,

THE following properties of numbers have not been noticed in any work of Algebra that I am aware of. If on inspection you find them to be new, you may think them sufficiently curious for insertion in your Philosophical Journal.

It seems not impossible that they may admit of some useful application in analysis; but at any rate they may be of service to persons entering on the study of algebra, or even to persons engaged in tuition, from the inexhaustible fund of examples the formulæ will supply. They are exhibited in the forms they assume when r is negative as well as positive; and when the number of terms is even as well as odd. Three of them have already appeared before the public, but without any demonstration; they are here inserted with the investigations.

Kensington, Feb. 23, 1835.

Theorem I.

$$(1.)\quad \frac{1+r^{2^n}+r^{2.2^n}\ldots\ldots r^{(m-1)2^n}}{1+r+r^2\ldots\ldots r^{m-1}} = \{1-r+r^2\ldots\ldots r^{m-1}\}$$

$$\times\left\{1-r^2+r^4\ldots\ldots +r^{(m-1)2}\right\}$$

$$\ldots\ldots\ldots \times\left\{1-r^{2^{n-1}}+r^{2\cdot 2^{n-1}}\ldots\ldots r^{(m-1)2^{n-1}}\right\} \; m \text{ being odd.}$$

$$\text{Let}\quad 1+r^{2^n}+r^{2.2^n}+\ldots\ldots r^{(m-1)2^n} = \mathrm{S},$$

$$1+r+r^2+\ldots\ldots\ldots r^{m-1} = s;$$

then, since each of these is a geometric series, we have

$$\frac{\mathrm{S}}{s} = \frac{(r^{m2^n}-1)\,(r-1)}{(r^{2^n}-1)\,(r^m-1)}\quad (a).$$

But $r^{m.2^n}-1 = (r^{m.2^{n-1}}+1)(r^{m.2^{n-2}}+1)\ldots\ldots(r^m+1)(r^m-1)$ to $n+1$ terms;

$r^{2^n}-1 = (r^{2^{n-1}}+1)(r^{2^{n-2}}+1)\ldots\ldots(r+1)(r-1)$ to $n+1$ terms; therefore, by substitution, in equation (a), we have

$$\frac{S}{s} = \frac{(r^{m.2^{n-1}}+1)(r^{m.2^{n-2}}+1)\ldots\ldots(r^m+1)(r^m-1)(r-1)}{(r^{2^{n-1}}+1)(r^{2^{n-2}}+1)\ldots\ldots\ldots(r+1)(r-1)(r^m-1)}.$$

By elimination and separation of the factors,

$$(b.)\ \ldots\ldots \frac{S}{s} = \frac{r^{m.2^{n-1}}+1}{r^{2^{n-1}}+1}\cdot\frac{r^{m.2^{n-2}}+1}{r^{2^{n-2}}+1}\ldots\ldots\frac{r^{2m}+1}{r^2+1}\cdot\frac{r^m+1}{r+1}$$

to n terms.

But $\dfrac{r^{m.2^{n-1}}+1}{r^{2^{n-1}}+1} = r^{(m-1)2^{n-1}} - r^{(m-2)2^{n-1}} + \ldots\ldots r^{2.2^{n-1}} - r^{2^{n-1}} + 1$

$$\frac{r^{m.2^{n-2}}+1}{r^{2^{n-2}}+1} = r^{(m-1)2^{n-2}} - r^{(m-2)2^{n-1}} + \ldots\ldots r^{2.2^{n-2}} - r^{2^{n-2}} + 1$$

&c. &c. &c. &c.

$$\frac{r^m+1}{r+1} = r^{m-1} - r^{m-2} + \ldots\ldots\ldots\ldots r^2 - r + 1,$$ each series to m terms.

Hence by substitution in equation ($b.$) we have

$$\frac{1+r^{2^n}+r^{2.2^n}+\ldots\ldots r^{(m-1)2^n}}{1+r+r^2+\ \ldots\ldots\ldots r^{m-1}} = \left\{1-r+r^2\ldots\ldots+r^{m-1}\right\}$$

$$\times\left\{1-r^2+r^{2.2}\ \ldots\ldots\ +r^{(m-1)2}\right\}$$

$$\ldots\ldots\ \times\left\{1-r^{2^{n-1}}+r^{2.2^{n-1}}+\ \ldots\ldots\ r^{(m-1)2^{n-1}}\right\}$$

to n factors of m terms each.

Or, as it may be more compendiously written

$$\frac{1+r^{2^n}+r^{2.2^n}+\ldots+r^{(m-1)2^n}}{1+r+r^2+\ \ldots\ldots\ +r^{m-1}} = {}^{2}\left\{1-r+r^2\ldots\ldots r^{m-1}\right\}^n,$$

where the index n shows that there are n factors, and the index 2 that the indices of each succeeding factor are double of the preceding.

(2.) Hence it appears that if an odd number of terms of a geometric series be raised to any power of two, the sum of the terms so raised is divisible by the original series. Also that the quotient consists of a number of factors, each of which is a geometric series of the same number of terms as the original one, having the signs of the alternate terms negative, the number of series or factors being denoted by the index of two. The first factor is the original series with the signs of the alternate terms changed, and the indices of each succeeding factor obtained, by doubling those of the preceding.

Example.

Let $n = 1$, then by the formula

$$\frac{1+r^2+r^4+ \ldots\ldots r^{(m-1)\,2}}{1+r+r^2+ \ldots\ldots r^{m-1}} = 1-r+r^2+ \ldots\ldots r^{m-1}$$

or, $\left\{1+r+r^2+ \ldots\ldots r^{m-1}\right\} . \left\{1-r+r^2- \ldots\ldots r^{m-1}\right\}$

$$= 1+r^2+r^4+ \ldots\ldots r^{(m-1)\,2}$$

from which it appears that if an odd number of terms of a geometric series, be multiplied by the same terms with the signs of the alternate terms changed; the product will be the sum of the squares of the original series.

(3.) *Cor.* $\dfrac{1+r^{k2^p}+r^{2k2^p}+ \ldots r^{(m-1)k2^p}}{1+r^k+r^{2k}+ \ldots\ldots r^{(m-1)k}}$

$$= {}^{2}\left\{1-r^k+r^{2k}- \ldots\ldots r^{(m-1)k}\right\}^p.$$

(4.) *Cor.* 2. Every algebraical expression of the form $1+r^{2^p}+r^{2.2^p}+ \ldots r^{(m-1)2^p}$ is divisible into $p+1$ factors, each of which is a geometric series of m terms, and p of which factors have the signs of the even terms negative, thus

$$1+r^{2^p}+r^{2.2^p}+ \ldots\ldots r^{(m-1)\,2^p} = \left\{1+r+r^2+ \ldots r^{m-1}\right\} \times$$

$$\left\{1-r+r^2- \ldots\ldots r^{m-1}\right\} \times \quad \ldots\ldots\ldots\ldots\ldots$$

$$\left\{1-r^{2^{p-1}}+r^{2.2^{p-1}}- \ldots\ldots r^{(m-1)\,2^{p-1}}\right\} \text{ to } p+1 \text{ terms.}$$

It may be observed that this formula retains the same signs whether r be positive or negative.

(5.) If each side of theorem 1. be multiplied by the quantity

$$\frac{1+r+r^2+\ \dots\ -r^{m-2}+r^{m-1}}{1-r+r^2-\ \dots\ -r^{m-2}+r^{m-1}},\text{ we have}$$

Theorem II.

$$\frac{1+r^{2^n}+r^{2\cdot 2^n}+\dots\dots r^{(m-2)\,2^n}+r^{(m-1)\,2n}}{1-r+r-\ \dots\dots\ r^{m-2}+r^{m-1}}$$

$$=\left\{1+r+r^2+\ \dots\dots\ r^{m-2}+r^{m-1}\right\}\times$$

$$\left\{1-r^2+r^4-\ \dots\dots\ r^{(m-2)\,2}+r^{(m-1)\,2}\right\}\times\ \&c.\ \&c.\ \&c.\ \dots\dots$$

$$\times\left\{1-r^{2^{n-1}}+r^{2.2^{n-1}}-\&c.\ \dots\dots\ r^{(m-2)\,2^{n-1}}+r^{(m-1)\,2^{n-1}}\right\}\ \text{to } n$$

factors of m terms each; or,

$$\frac{1+r^{2^n}+r^{2.2^n}+\&c.\ \ \dots\dots\ r^{(m-2)\,2^n}+r^{(m-1)\,2^n}}{1-r+r^2-\&c.\ \dots\dots\ r^{m-2}+r^{m-1}}$$

$$=\left\{1+r+r^2+\&c.\ \dots\dots\ r^{m-2}+r^{m-1}\right\}\times$$

$$^2\left\{1-r^2+r^{2.2}-\ \dots\dots\ +r^{(m-1)\,2}\right\}^{n-1}.$$

(6.) *Cor.* $\dfrac{1+r^{k2^n}+r^{2k2^n}+\ \dots\dots\ r^{(m-1)\,k2^n}}{1-r^k+r^{2k}-\ \dots\dots\ r^{(m-1)\,k}}$

$$=\left\{1+r^k+r^{2k}\dots r^{(m-1)\,k}\right\}\cdot{}^2\left\{1-r^{2k}+r^{4k}-\dots r^{2(m-1)k}\right\}^{n-1}$$

Theorem III.

(7.) Let p, q, r be any numbers of which $p > q$ and m an odd number, then

$$\frac{1+r^{2^p}+r^{2.2^p}+\&c.\ \dots\dots\ r^{(m-2)\,2^p}+r^{(m-1)\,2^p}}{1+r^{2^q}+r^{2.2^q}+\&c.\ \ \dots\dots\ \ r^{(m-2)\,2^q}+r^{(m-1)\,2^q}}$$

$$=\left\{1-r^{2^q}+r^{2.2^q}-\&c.\ \dots\dots\ r^{(m-2)\,2^q}+r^{(m-1)\,2^q}\right\}$$

$$\times\left\{1-r^{2^{q+1}}+r^{2.2^{q+1}}-\&c. \ldots\ldots r^{(m-2)\,2^{q+1}}+r^{(m-1)\,2^{q+1}}\right\}$$

$$\times\left\{1-r^{2^{q+2}}+r^{2.2^{q+2}}-\&c. \ldots\ldots r^{(m-2)\,2^{q+2}}+r^{(m-1)\,2^{q+2}}\right\}$$

$$\times \quad \&c. \qquad \&c. \qquad \&c.$$

$$\left\{1-r^{2^{p-1}}+r^{2.2^{p-1}}-\&c. \ldots\ldots r^{(m-2)\,2^{p-1}}+r^{(m-1)\,2^{p-1}}\right\}$$

Dem.

By Art. 1. $$\frac{1+r^{2^p}+r^{2.2^p}+\&c. \ldots\ldots r^{(m-2)\,2^p}+r^{(m-1)\,2^p}}{1+r+r^2+\&c. \ldots\ldots r^{(m-2}+r^{m-1}}$$

$$={}^2\left\{1-r+r^2-\&c. \ldots\ldots r^{m-2}+r^{m-1}\right\}^p.$$

By dividing each side of the equation by $1-r+r^2-\&c.$ $\ldots\ldots -r^{m-2}+r^{m-1}$

we get $$\frac{1+r^{2^p}+r^{2.2^p}+\&c. \ldots\ldots +r^{(m-2)\,2^p}+r^{(m-1)\,2^p}}{1+r^2+r^{2.2}+\&c. \ldots\ldots r^{(m-2)\,2}+r^{(m-1)\,2}}$$

$$={}^2\left\{1-{}^2+r^{2.2}-\&c. \ldots\ldots r^{(m-2)\,2}+r^{(m-1)\,2}\right\}^{p-1}$$

Dividing each side by $1-r^2+r^{2.2} \ldots\ldots r^{(m-2)\,2}+r^{(m-1)\,2}$ we have

$$\frac{1+r^{2^p}+r^{2.2^p}+ \ldots\ldots -r^{(m-2)\,2^p}+r^{(m-1)\,2^p}}{1+r^{2^2}+r^{2.2^2}+ \ldots\ldots -r^{(m-2)\,2^2}+r^{(m-1)\,2^2}}$$

$$={}^2\left\{1-r^{2^2}+r^{2.2^2}-\&c. \ldots\ldots -r^{(m-2)\,2^2}+r^{(m-1)\,2^2}\right\}^{p-2}$$

and by performing the division in like manner q times, we have at length

$$\frac{1+r^{2^p}+r^{2.2^p}+\&c.\ldots\ldots -r^{(m-2)\,2^p}+r^{(m-1)\,2^p}}{1+r^{2^q}+r^{2.2^q}+\&c. \ldots\ldots r^{(m-2)\,2^q}+r^{(m-1)\,2^q}}$$

$$={}^2\left\{1-r^{2^q}+r^{2.2^q}-\&c. \ldots\ldots r^{(m-2)\,2^q}+r^{(m-1)\,2^q}\right\}^{p-q}$$

$$\text{Or, } \frac{1+r^{2^p}+1^{2.2^p}+\ \dots\dots\ r^{(m-1)2^p}}{1+r^{2^q}+r^{2.2^q}+\dots\dots\ r^{(m-1)2^q}}$$

$$= \left\{1-r^{2^q}+r^{2.2^q}-\ \dots\dots\ r^{(m-1)2^q}\right\} \times$$

$$\left\{1-r^{2^{q+1}}+r^{2.2^{q+1}}-\dots\dots\ r^{(m-1)2^{q+1}}\right\}$$

$$\dots\dots\dots \left\{1-r^{2^{p-1}}+r^{2.2^{p-1}}-\dots\dots\ r^{(m-1)2^{p-1}}\right\}$$

to $p-q$ factors of m terms each.

8. From this it appears that if an odd number of terms of a geometric series be separately raised to the power of 2^p, and divided by the same terms raised to the power of 2^q, the quotient will consist of $p-q$ factors, each of which is a geometric series of the same number of terms as the original one, with the signs of the even terms negative.

[To be continued.]

XXXIV. *On the Presence of Titanic Acid in the Blood.* By *Mr.* G. O. Rees.

To Richard Phillips, Esq., F.R.S., &c.

Sir,

You will much oblige me by inserting the following experiments in the London and Edinburgh Philosophical Magazine and Journal of Science.

Your obedient Servant,

G. O. Rees.

While making some further observations on the presence of titanium in organic matter, I was induced to examine the blood, in order to assure myself that its existence in that fluid had not been overlooked. For that purpose the following experiments were made. A portion of incinerated blood was digested in strong nitro-muriatic acid at a boiling temperature: the solution so formed was decanted from the insoluble residue, which consisted of granular white particles in admixture with a portion of carbon that had escaped dissipation. The decanted solution was evaporated to dryness. Very dilute sulphuric acid was next boiled on the dry mass for a few minutes, when a considerable quantity of a fawn-coloured powder was observable at the bottom of the vessel: this powder was

washed with distilled water, dried, and heated to redness in a platinum crucible; it became of a dark colour, and when cold had a distinct reddish hue, owing, doubtless, to a portion of phosphate of iron in admixture, as that substance does not redissolve with the dried chloride. The mass was therefore boiled in aqua regia, when a light coloured powder was left undissolved: this, on being examined before the blowpipe on a platinum support, gave a yellow bead (becoming colourless when cold) in the outer flame; and a yellow bead, becoming reddish while cooling, and purple inclining to blue when cold, if the inner flame was directed on it.

A second portion of incinerated blood was similarly treated, excepting that the dried chloride was (as several digestions with aqua regia were had recourse to) each time washed away from the mass in the vessel used for the digestions. By this means a residual mass was procured, of a white colour inclining to gray; this was fused with carbonate of soda, which produced a yellow colour when heated, becoming nearly white when cold. Distilled water was boiled on the fused mass, when a light flocculent white precipitate was seen floating in the liquor, and a heavier fawn-coloured powder (which gave the reactions of titanic acid before the blowpipe) appeared at the bottom of the vessel. The flocculent precipitate was collected and dissolved in cold dilute muriatic acid: the solution gave a dark green coloured precipitate when neutralized with ammonia and tested with hydrosulphuret of ammonia, and a reddish brown precipitate with infusion of galls; the sulphuret when collected and ignited behaved as titanic acid before the blowpipe. In every specimen I have examined, an insoluble residue has been observable, though strong nitromuriatic acid has been used as a solvent: this insoluble matter in every instance has been of a white or dingy white colour, becoming yellow when fused with alkaline carbonate, but not exhibiting that phænomenon when heated alone to the same extent as the titanic acid of the mineral kingdom. As I have not yet made any quantitative analysis of the incinerated blood, I cannot say that the iron exists as titanate in that substance, though titanic acid be present; but its behaviour would seem to indicate the necessity of such being the case. I have only to add, that a recent communication regarding the existence of titanic acid in Hessian crucibles can in no way interfere with any of my observations, as the whole of the crucible experiments I have detailed were conducted in platinum vessels.

Guy's Hospital, Feb. 12, 1835.

XXXV. *On the Attraction of an Homogeneous Ellipsoid on an external Particle.* By J. B.*

LET a, b, c be the semiaxes of the ellipsoid, a the greatest and b the least, $\delta =$ distance of external particle from the centre, assumed as the origin of coordinates, λ, μ, ν the angles which the line δ makes with the semiaxes a, b, c, M = mass of the ellipsoid, μ the external particle, and f the intensity of attraction at the unit of distance, D the attraction along the line δ; then in the expression $V = \iiint \frac{dm}{\delta}$, expanding $\frac{1}{\delta}$, multiplying by dm, integrating and including the terms as far as the third powers of the coordinates of dm, and making the necessary reductions, we have this general formula:

$$D = \frac{f\mu M}{\delta^2}\left\{1 + \frac{3}{10}\left\{\frac{(3\cos^2\lambda - 1)a^2 + (3\cos^2\mu - 1)b^2 + (3\cos^2\nu - 1)c^2}{\delta^2}\right\}\right\}$$

2. Let A, B, C be the attractions on three particles at equal distances from the centre in the axes produced; then

$$A = \frac{f\mu M}{\delta^2}\left\{1 + \frac{3}{10}\left(\frac{2a^2 - b^2 - c^2}{\delta^2}\right)\right\};$$

$$B = \frac{f\mu M}{\delta^2}\left\{1 + \frac{3}{10}\left(\frac{2b^2 - a^2 - c^2}{\delta^2}\right)\right\};$$

$$C = \frac{f\mu M}{\delta^2}\left\{1 + \frac{3}{10}\left(\frac{2c^2 - a^2 - b^2}{\delta^2}\right)\right\}.$$

Adding these three formulæ, $A + B + C = \frac{3f\mu M}{\delta^2}$, or the sum of the attractions of an ellipsoid on three particles at equal distances from the centre in the axes produced = three times the spherical attraction of the same mass on a particle at the same distance.

3. Hence, also, the attraction of the ellipsoid is greatest in the direction of the greater axis, and greater than that of a sphere of the same mass on an equidistant particle; and that in the direction of the lesser axis is the least.

4. If the squares of the semiaxes are in arithmetical progression, the attraction of the ellipsoid on a particle situated in the mean axis = to that of a sphere of the same mass on a particle at the same distance, for $(2c^2 - a^2 - b^2)$ in this case $= 0$.

5. Let there be two homogeneous concentric ellipsoids of

* Communicated by the Author.

the same density, whose semiaxes are a, b, c and α, β, γ respectively, such that $a^2-c^2 = \alpha^2-\gamma^2 = k^2$ and $c^2-b^2 = \gamma^2-\beta^2 = h^2$; and let two particles be assumed, p and ϖ, whose coordinates are $l\,\alpha$, $m\,\beta$, $n\,\gamma$, and $l\,a$, $m\,b$, $n\,c$; $l^2+m^2+n^2$ being $= 1$, it can be easily shown that the particles p and ϖ are on the two ellipsoids. Calling the external ellipsoid E and the internal one I, then the attraction of E on ϖ is to the attraction of I on p, in a direction perpendicular to one of the principal planes, as the product of the axes of E in that plane is to the product of the axes of I in the same plane; which is the celebrated theorem given by Mr. Ivory.

First, let the particles p and ϖ be situated at the surfaces in the axes of γ and c, then $l = 0$, $m = 0$, and $n = 1$, and the attraction of I on p is by the formula as

$$\frac{4\pi f\,a\,b\,c}{3\gamma^2}\left\{1+\frac{3}{10}\left(\frac{2c^2-a^2-b^2}{\gamma^2}\right)\right\}$$

$$=\frac{4\pi f\,a\,b\,c}{3\gamma^2}\left\{1+\frac{3}{10}\left(\frac{h^2-k^2}{\gamma^2}\right)\right\},$$

and the attraction of E on p is as

$$\frac{4\pi f\,\alpha\,\beta\,\gamma}{3\gamma^2}\left\{1+\frac{3}{10}\left(\frac{2\gamma^2-\alpha^2-\beta^2}{\gamma^2}\right)\right\}$$

$$=\frac{4\pi f\,\alpha\,\beta\,\gamma}{3\gamma^2}\left\{1+\frac{3}{10}\left(\frac{h^2-k^2}{\gamma^2}\right)\right\},$$

Hence the attraction of I on p is to the attraction of E on the same particle p as $a\,b\,c : \alpha\,\beta\,\gamma$. Now, if through the internal point ϖ an ellipsoid *similar* to the external E concentric, and similarly situated, be drawn, the attraction of E on p : the attraction of E on $\varpi :: \gamma : c$; therefore the attraction of I on p : the attraction of E on $\varpi :: a\,b : \alpha\,\beta$.

Now, if the particles be not at the extremities of c and γ, let their coordinates to the plane of $x\,y$ be $n\,c$ and $n\,\gamma$, and let the particles be p' and ϖ'; then the attraction of E on the particles p and p' is as their perpendicular distance from a principal plane as γ and $n\,\gamma :: 1 : n$. In the same way the attraction of I on ϖ and $\varpi' :: c : n\,c :: 1 : n$. Hence attraction of I on p' : attraction of E on $\varpi' :: a\,b : \alpha\,\beta$.

6. Should the ellipsoid become an oblate spheroid $a = c$, and let $a^2-b^2 = a^2 e^2$, and the formula becomes

$$D = \frac{f\mu M}{\delta^2}\left\{1+\frac{3}{10}\,\frac{a^2 e^2}{\delta^2}\left(1-3\cos^2\mu\right)\right\}.$$

7. When $\cos^2\mu = \frac{1}{3}$, the attraction is the same as that of

a sphere of the same mass on an equidistant particle, but cos μ is nearly = sine of latitude; hence the attraction along a line which makes with the axis an angle whose cos $= \frac{1}{\sqrt{3}}$, is the same as that of a sphere of the same mass.

8. When the particle is on the equator of the oblate spheroid $\delta = a$ and $\mu = 90°$; hence $A = \frac{4\pi f b}{3}\left\{1 + \frac{3}{10} e^2\right\}$, and if e be small $e^2 = 2\varepsilon$ nearly; hence $A = \frac{4\pi f b}{3}\left\{1 + \frac{3}{5}\varepsilon\right\}$.

9. If the particle be at the pole of the oblate spheroid $\delta = b$, and neglecting powers of ε above the first,

$$P = \frac{4 f b}{3}\left\{1 + \frac{4}{5}\varepsilon\right\}.$$

10. Should the ellipsoid become a prolate spheroid round the axis of a, the formula becomes

$$D = \frac{f M}{\delta^2}\left\{1 + \frac{3}{10}\left(\frac{3\cos^2\lambda - 1}{\delta^2}\right) a^2 e^2\right\} b \text{ being } = c.$$

If the point be at the pole of the spheroid $\cos\lambda = 1$, and $\delta = a$, and the formula $P' = \frac{4\pi f b}{3}\left\{1 + \frac{1}{5}\varepsilon\right\}$.

11. If at the equator $\delta = b$ and $\cos\lambda = 0$ and the formula becomes $B = \frac{4\pi f b}{3}\left\{1 + \frac{2}{5}\varepsilon\right\}$, omitting the powers of ε above the first.

Trinity College, Dublin, Nov. 12, 1834.

XXXVI. *On the Refraction and Polarization of Heat.* By James D. Forbes, *Esq., F.R.SS. L. & E., Professor of Natural Philosophy in the University of Edinburgh.*

[Continued from p. 142.]

§ 2. *On the Polarization of Heat by Tourmaline.*

18. It is well known that two slices of tourmaline cut parallel to the axis of the crystal, as they are looked through with their axes parallel or perpendicular to one another, transmit a great portion of the incident light in the one case, and almost wholly intercept it in the other.

19. It occurred to me as a curious question, at an early period of my researches, whether non-luminous heat would un-

dergo any similar change in similar circumstances. I made a preliminary experiment with heat from an oil-lamp (not an Argand), and though, when the axes were crossed, the whole light was stopped, the heat transmitted appeared to be as intense as before. The tourmalines which I employed were mounted on glass, and were kindly lent to me by the Rev. Mr. Craig. Struck with the singularity of the result, I repeated the experiment with additional precautions, and I found that some circumstances prevented this statement from being true in all its generality. The quantity of heat transmitted being very small, the lamp, the tourmalines, and the pile were very near to one another; and, as the tourmaline absorbs heat with great rapidity, I found that a minute difference might exist if the experiment was made first with the axes parallel, and then with the axes crossed, which difference might yet be made up by the secondary radiation from the heated tourmaline, which was constantly becoming more intense. Such at least appeared to be the chief source of error, which I am particular in stating, because I afterwards discovered that M. Melloni had been led to the very same conclusion as I at first was, and had published it.

20. When I proceeded to verify my results by a series of successive observations, under the two conditions of axes parallel and axes crossed, so as to eliminate any error from a constantly progressive change, I perceived my mistake. As this illustrates the method by which almost all my observations have been reduced, I shall give an example. Two measures of intensity in the position where least light was transmitted, which is marked *Dark*, have their mean taken, which is then compared with the intervening observation in the position of greatest illumination, which is marked *Light*. These tourmalines we may call A and B.

1834, Dec. 4.—*Oil Lamp* six inches from Centre of the Pile.*

	Dark.	Mean.	Light.	Ratio.
Deviations of galvanometer.	$4\frac{1}{4}^\circ$			
		$4^\circ{\cdot}5$	$5^\circ{\cdot}2$	86 : 100
	$4\frac{3}{4}$			
		5·0	6·0	83 : 100
	$5\frac{1}{4}$			
		5·2	6·0	86 : 100
	5			
		5·4	6·5	83 : 100
	$5\frac{3}{4}$			

* The oil lamp used when not expressly called "Argand," was Locatelli's lamp with a solid square wick, which is what M. Melloni employed.

Another series on a different day gave the following quantities per cent. 91, 82, 94. Mean of the whole, 86·4 : 100.

21. Having obtained these decisive results, I proceeded to operate with other sources of heat, and with different tourmalines. Anxious to avoid the interposition of glass, I had a pair of tourmalines of large size cut without any support. But the best kind will not bear this, and they polarized imperfectly. Only fifteen sixteenths (approximately) of the light in the bright position was stopped in the dark, whilst with the tourmalines A and B every vestige of the brightest gas flame was excluded. With these tourmalines (which may be called C and D) I verified the general conclusions. I was unable to get sufficient effect from non-luminous heat to verify the law in that case.

22. I had two very fine tourmalines cut and mounted on extremely thin glass. These we may call E and F. With them I was enabled to extend and verify the law of polarization even to the case of non-luminous heated brass, (whose temperature when warmed by alcohol, M. Melloni estimates at 390° cent. = 734° Fahr.) And it is worthy of observation that among twenty-nine pairs of comparative observations, made with three sets of tourmalines, and heated from the following sources, Argand lamp, simple oil lamp, platinum rendered incandescent by alcohol, and non-luminous hot brass, there was only *one* which did not give positive indications of polarization. The effect, however, with non-luminous heat is extremely feeble, and the percentage very small, because it is with great difficulty that we can obtain results at all with the interposition of two plates of glass, and two of tourmaline (however thin), and a large portion of heat which reaches the pile is derived from conduction, and therefore diminishes the proportion of polarization.

23. It is very important to observe, that in this and all similar cases, *the effect of conduction or the secondary radiation of heat from screens always tends to disguise, and never to produce the differences of which we are in search*; that is, so long as the *means* of alternate observations are taken in the way we have described.

24. The following are the general results of my experiments on tourmaline.

Source of Heat.	No. of Comparisons. A and B	E and F	Proportions of Heat polarized by Tourmalines A and B	E and F*
Argand lamp, ...		3		16 per cent.
Oil lamp, ...	7	3	14 per cent.	11 per cent.
Incandescent platinum,	4	3	15 ...	12 per cent.
Brass at 700°, ...		7 (1 negative)		3 per cent.

* It appears that the axes of E and F were not precisely crossed in these experiments.

I cannot, therefore, entertain any doubt on the polarization of heat by tourmaline, notwithstanding the opposite result which M. Melloni (and I also at first) obtained.

25. Some very curious considerations arise from the study of these facts. Since 84 per cent. of the heating rays of an Argand lamp pass through the second tourmaline in the case where the light is entirely stopped, we must adopt one of two conclusions: either that the heat which *necessarily* accompanies light is excessively small, or else that radiant light during its instantaneous passage through a medium, is capable of being *converted* into radiant heat. The latter supposition we have no analogies strong enough to warrant us to adopt, though were heat really not polarized by tourmaline, we must have done so. All our experiments point to the first, namely, that heat, though intimately partaking of the nature of light, and accompanying it under certain circumstances (as refraction and reflection), is capable of almost complete separation from it in others. Thus, almost all the heat is stopped by a plate of alum, which transmits nearly the whole light, whilst a second plate of tourmaline stops the whole light, but transmits a large share of the heat.

26. The tourmaline affords a precious method of investigating the influence of light, since the quantity of matter to be traversed is exactly the same, whatever be the direction of the axes of the crystal. In this it differs from all other modes of absorption.

27. M. Melloni has proved that the more light that accompanies heat, the greater power it has to traverse most media, such us clear glass or alum. I made several experiments on the *quality* of the heat which passed through the tourmalines in their darkest and in their brightest positions, and I always found that the presence of the light materially increased the power of the heat to permeate such screens, though we have seen how little it added to the *quantity*.

28. This fact, namely, that by sifting, as it were, heat separate from light, we give to it the characters of non-luminous heat, or heat of low temperature, and small refrangibility, such as exists beyond the red extremity of the spectrum, seems so far congenial with analogy. But according to Melloni's experiments, this does not hold with other degrees of *sifting* of heat. Thus the absorption of all rays of light, except the blue, the yellow, or the red, by coloured glasses, does not give the peculiar character to the heat which it possesses, when it accompanies light in the process of refraction, namely, that of permeating screens (in general) more readily as the refrangibility is greater. Hence I conceive we must conclude, that

heat in the spectrum *accompanies* the light, and has corresponding properties, but that in general these properties are independent of the nature of the accompanying light.

29. The only fact which appeared to militate against this view, so far as coloured media were concerned, was the case of *green* light. It appeared probable that this arose from some peculiarity in the absorptive nature of the material, not from its colour. To investigate this point, I tried the relative transparency (or *diathermancy*, to borrow a word from M. Melloni,) of screens for the heat of various coloured flames. I did not find that marked peculiarity in the *green*, which M. Melloni observed in the absorptive action of green glass. The following results are not pretended to be numerically accurate, but they are probably nearly comparable. The flames were obtained from alcohol, combined with the following substances: for the red, nitrate of strontia (the muriate is better); the yellow, with muriate of soda; the green, boracic acid; the blue, pure alcohol. The unsteadiness of intensity of an alcohol flame prevents great numerical accuracy.

	Number of Rays of Heat out of 100 transmitted by		
Colour of Flame.	Alum.	Glass.	Rock Salt.
Red,....................	11	26	85
Yellow, ...	$11\frac{1}{2}$	28	87
Green,................	11	26	84
Blue, ...	10	30	83

The differences are certainly within the limits of errors of observation.

30. I am disposed to believe, however, that in these experiments, as well as Melloni's, some effect is probably due to the simple presence of light of a particular quality, though its heating power may be small. This my experiments with tourmalines countenance. We can hardly, however, look for a solution of these difficulties, until some of the most stubborn difficulties in the theory of light, the laws of dispersion and absorption (and especially that peculiar absorptive power which permits the tourmaline only to transmit one polarized pencil,) are completely overcome. Meanwhile, we pass with pleasure to the consideration of some of those properties of heat which serve to connect it with the best determined and best explained departments of optics.

§ 3. *On the Polarization of Heat by Refraction and Reflection.*

31. Soon after the discoveries connected with the polarization of light, which illustrated the earlier part of this century, the question of the polarization of heat was taken up by Malus

and Berard.* In the case of heat accompanying solar light, it was decisively proved, as might have been anticipated; but in the case of heat from terrestrial, and especially non-luminous sources, though M. Berard considered that he had proved it, he gives no *quantitative* measures which could enable us to judge of the evidence, nor does it appear that subsequent experimenters have been able to verify the assertion.†

32. The importance of the subject will be estimated, when we consider the very definite laws to which the polarization of light is subjected, and the accuracy with which they are represented upon the undulatory hypothesis. If heat, when wholly deprived of light, be subjected to similar modifications, our progress in acquiring a knowledge of the true nature of heat will be greatly advanced by our previous analogical acquaintance with the laws of light.‡

33. I had been led to make the experiment with tourmalines, because of the convenience with which all experiments on transmitted heat are made by means of the multiplier. But at the same time it occurred to me, that the transmitted pencil of heat passing through laminæ at the polarizing angle might likewise be adapted to the instrument. I had previously noticed the large proportion of heat transmitted by thin plates of mica, and I thought of applying bundles of mica-plates placed at the polarizing angle, and so cut from the plate, that

* Mémoires d'Arcueil, tom. iii.

† See Professor Powell's papers in the Edinburgh Journal of Science, Second Series, vols. vi. and x.

‡ The importance of analogies in science has not perhaps been sufficiently insisted on by writers on the methods of philosophizing. A clear perception of *connexion* has been by far the most fertile source of discovery. That of gravitation itself was only an extended analogy. The undulatory theory of light has been preeminently indebted to the co-ordinate science of acoustics, which afforded to Dr. Young the most plausible basis of his curious and original investigations; and unless that science had existed, it may be doubted whether such a speculation would ever have been invented, or, if invented, would have been listened to. The penetrating sagacity of M. Fresnel, in his prosecution of the subject, has led him to draw from mechanical and mathematical analogies, accurate representations of laws which no strict reasoning could have enabled him to arrive at. Of this his marvellous prediction of the circular polarization of light by two total reflections in glass, is the most prominent example, a conclusion which no general acuteness could have foreseen, and which was founded on the mere analogy of certain interpretations of imaginary expressions. The mere reasoner about phænomena could never have arrived at the result,—the mere mathematician would have repudiated a deduction founded upon analogy alone. The cause of the long postponement of the discovery of electro-magnetism was the complete apparent breach of analogy between the modes of action of the electric and magnetic forces, and any others previously known.

the plane of incidence corresponded with one of the *neutral sections* of the mica-plate, (the section used was that *perpendicular* to the principal plane,) so that the transmitted pencil would be polarized exactly similarly to that refracted through glass or any singly refracting medium.

34. I prepared two pairs of bundles of plates of mica of this description, the first (which I called A and B) having a thickness of about one fiftieth of an inch, and was split into about ten plates, whilst the others (C and D) were only half the thickness, and contained but half as many reflecting surfaces. I found that these plates, placed at the proper angle, polarized light very satisfactorily. On applying them to heat, I had the satisfaction of finding that not only was heat from an oil lamp most decisively polarized, but also that from a brass plate warmed by alcohol, but so as to be quite invisible in the dark, having probably a temperature (as before mentioned) of about 700° Fahr. These experiments were made on the 22nd of November last, and were afterwards amply confirmed*.

35. It is to this mode of observing that I attribute chiefly the success of my after inquiries. The mode of reflection for polarizing is attended with so much inconvenience where a thermometer is concerned, and especially with the multiplier, as to render the employment of it tedious and incommodious; whereas by having two bundles of mica-plates arranged in square tubes, so that the one fits the extremity of the thermal pile, and the other slips into the first, and by turning it round we get observations with plates, whose planes of incidence for rays passing along the axis of the tube, are inclined 0°, 90°, 180°, or 270° to one another, the direction of the ray is generally in a single straight line, and the observations are made in the same manner, and with equal facility as in ordinary experiments on transmission. I have little doubt that in this way the polarization of heat might be proved without the aid of the thermo-multiplier. The plates were fixed at the polarizing angle *for light*. After what has been said, art. (16), on the refrangibility of heat, it is clear, that the alteration of the polarizing angle, in order to accommodate it to heat, could hardly amount (by Sir David Brewster's law) to a sensible quantity.

* I did not see M. Melloni's second paper till the 10th of December, after I had obtained the chief fundamental results contained in this paper. It does not appear, however, that M. Melloni had thought of applying his instrument to any question of polarization except that of tourmaline, and in a note he alludes to the objections which had been urged against Berard's conclusions, objections which he does not consider to have been overcome. —*Ann. de Chimie*, lv. 374.

36. I fitted up two other bundles of mica-plates, in square pasteboard tubes of the kind described, which were marked E and F, the other plates being occasionally substituted, in order to verify the results, and to show that no accidental peculiarity of the plates could account for the differences observed. My experiments were usually made thus. The tube E was fixed to the pile; the tube F, containing the other plate, had an index, which pointed to 0° when the two plates were parallel, to 90° when they were at right angles, &c. Five observations were taken; at 0°, 90°, 180°, 270°, and again at 0°. The mean of the first and last were taken; then the mean of this, and the indication at 180°, and the difference between this and the mean at 90° and 270°, was considered as the polarizing effect. An example will best illustrate this:—

1834, Nov. 26.—*Brass heated by Alcohol: $5\frac{1}{2}$ inches from centre of Pile.*

		Deviation.
Analysing plate (E) at 0°; polarizing plate (F) at	0°	.. $6\frac{1}{2}$°
	90	.. $5\frac{1}{4}$
	180	.. 7
	270	.. 6
	0°	.. $7\frac{1}{4}$

Mean at 0° ... 6°·9
180° ... 7 ·0

Mean, ... 6 ·9
Mean at 90° and 270°, .. 5 ·6 } Ratio 100 : 81, or 19 per cent. polarized.

The general concordance of these experiments will be gathered from the following list of results.

37. With *non-luminous heat* from *brass* about 700°; ratio of effect, when plates E and F were *parallel* and *crossed*, 100 : 78; 100 : 76; 100 : 80 *; 100 : 81 (from five observations each), with plates E and A (from three observations each), 100 : 74; 100 : 59; 100 : 68; 100 : 60; with A and B, ratios 100 : 78; 100 : 72.

38. With *non-luminous heat* from *mercury*, about 500°, plates E and F; 100 : 77; 100 : 90, plates E and A; 100 : 88; with A and B, 100 : 78.

39. But even with heat from water below the boiling-point, I was able, by the improved method of observing the galvanometer, art. (5), (6), to establish completely the polarizing effect. One series of six comparisons (conducted as in (20),)

* Plate B was used to polarize in this experiment.

gave for the proportions of heat transmitted, when the plates E and F were *parallel* and *crossed*, 100 : 93 ; another of eight comparisons, gave 100 : 96 ; a third, of eight, 100 : 92. Among these twenty-two comparisons, only *one* gave a result slightly negative.

40. With *platinum rendered incandescent* by alcohol, the effect appears decidedly greater than with any other source of heat I have tried. Plates E and F ; ratios of effect when *parallel* and *crossed*, 100 : 59 ; 100 : 62 ; 100 : 66 ; 100 : 54. The brilliancy of the incandescence affects materially the transmission.

41. *Alcohol flame*, as might be anticipated, is less steady ; means from sets of five observations, with plates E and F ; 100 : 66 ; 100 : 72 ; 100 : 79 ; 100 : 42 ; 100 : 62.

42. With the simple *oil-lamp* of Locatelli ; plates E and F, the ratios are 100 : 76 ; 100 : 73·5 ; 100 : 79.

43. With *Argand lamp*, and glass chimney ; plates E and F ; ratios, 100 : 70 ; 100 : 72 ; results very steady.

44. When we combine these results*, and compare them with the quantity of light polarized, which was derived from some rude photometrical experiments, which agreed pretty nearly, we get the following approximations to the degrees of polarization, by a given combination, and depending on the source of heat.

Source of Heat.	Rays out of 100, polarized by transmission through mica plates E. and F.
Argand lamp (glass chimney), . . .	29
Locatelli lamp, ...	24
Alcohol flame, ...	36
Incandescent platinum, ...	40
Brass, about 700°, ...	22
Mercury, about 500° (in crucible), .	17
Water under 200°, ...	6
Proportion of *light* polarized,* . . .	89

45. So completely and satisfactorily made out does the polarization of heat appear by these concurrent experiments, that it was little more than a matter of curiosity to verify it in the

* It should be remarked, that these experiments contain *all* the measures I have made with a view to this determination, except two, which were made the very first day I discovered the fact, and which were not accurate enough to be employed. I mention this, because, in such experiments, it is important to be assured of the constancy and marked nature of a result, which can only be appreciated by keeping back no fairly made observation.

† Though I am not aware of any source of error, I cannot help thinking, that, in this case, and in that of the tourmaline, art. (21.), the defalcation of light is estimated too high.

case of reflection from surfaces, as well as in that of transmission through plates. This, however, I also established, though not without much more trouble than the other, the change of direction of the ray by reflection presenting a troublesome necessity for making the thermometric instrument, that is, the pile, moveable; at least, this was the most unexceptionable method. I fully established the fact of comparative non-reflection from a second reflecting plate of mica, the plane of incidence being at right angles to the first; but I had more reason than ever to be satisfied of the value of the simple and effective method of transmission through thin mica-plates. In fact, it was only by the aid of that method that I could have advanced to the still more delicate inquiries which, by the constancy of my first results, I was encouraged to undertake.

[To be continued.]

XXXVII. *Reviews, and Notices respecting New Books.*

The Chemical Catechism, Thirteenth Edition. By the late Samuel Parkes, F.L.S., G.S., W.S., M.R.I., &c. *Revised, and adapted to the present state of Chemical Science,* by E. W. Brayley, Jun., A.L.S., of the London Institution. *London,* 1834. 8vo. pp. xl. *and* 681 : *with a frontispiece and two other plates.*

FEW elementary works on any branch of science, we believe, have attained a popularity so great or so enduring, as the Chemical Catechism of the late Mr. Parkes. Coeval, in its original publication, with the first great analytical discoveries of Davy, it supplied the public demand for knowledge respecting the phænomena and objects of Chemistry, which those discoveries had either mainly excited, or if they did not actually excite, had immensely promoted and increased. As the science progressed, displaying fresh wonders to attract the lover of novelty and deeper truths to interest the philosophical student, as well as more and still more important applications to the arts of life, new editions of the Chemical Catechism were prepared by the author to meet the still increasing demand; into which he introduced, from time to time, as they were elicited, the new facts of Chemical discovery. Between the first appearance of the work in the year 1806 and the publication of the edition now before us—a space of about twenty-seven years—nearly a thousand copies, upon an average, as we gather from one of the " Advertisements," were disposed of every year.—Ample reasons these for the publication of a new edition, adapted to the existing state of Chemical knowledge.

The plan of this work is too well known to the public to require particular explanation : suffice it to say that the body of it consists of a popular elementary view of Chemical Science, delivered in the catechetical form, to which are attached numerous illustrative notes, giv-

ing, in comparative detail, the history of the subjects more summarily treated of in the text or Catechism itself.

In the preparation of the present edition, it is stated by the editor, Mr. Brayley Jun., in his "Advertisement," that it has been his purpose to introduce every new fact in Chemistry, possessing a degree of general importance entitling it to notice in a popular elementary work, which had been discovered since the date of the preceding edition (1826), and to adapt the Chemical Catechism to the actual condition of the science; but at the same time sedulously to preserve that *character* and general arrangement, which had acquired, for the previous editions, a popularity so extensive and so lasting. He has endeavoured, therefore, he states in continuation, to treat every new subject in the manner in which the Author would himself have treated it; and in those cases in which the Author's original remarks were affected by the progress of science, he has been careful rather to make them valid, by giving them a correct turn, than to omit or materially to alter them. Where also, in former editions of the Work, a particular statement has been made upon an important subject, which subsequent discoveries have impugned, the Editor has frequently retained the statement, adding the requisite corrections, instead of expunging it; in order that readers who have derived their views on the subject alluded to from former editions, and who may refer to it as treated in the present, may observe the correction, and be thus informed of the truth as now known. The same course has been pursued, he intimates, in other instances, for the sake of preserving a notice of the history of the science on the point in question.

The principal subjects now introduced into the Chemical Catechism for the first time, or the history of which, it is stated, has been so materially improved as to render them virtually new, appear to be the following:—the phænomena of the Conduction and Radiation of Caloric; the new earth Thorina, as now recognised by Berzelius; the Vegeto-alkalies; the new mineral alkali, Lithia; Bromine, Fluorine, and Boron; the Metals of the Earths, as obtained and described by Berzelius, Wöhler, Oersted, and Bussy; and the new metal more recently discovered, Vanadium. A Table of Chemical Equivalents has also been added to the "Chemical Tables" at the end of the volume; and the higher temperatures mentioned in the "Table of the Effects of Heat," have been corrected, agreeably to the pyrometrical researches of Mr. Daniell. A variety of other subjects are also noticed for the first time in the present edition, but more briefly than the former, and chiefly in notes, in connexion with the history of the substances or principles to which they relate. Among these we observe Saussure's experiments on the variations in the proportion of carbonic acid contained in the air; the identity of gases and vapours as shown by Mr. Faraday; the present state of our knowledge respecting the proportions of oxygen and nitrogen in atmospheric air; the true nature of glass; the use of alumina in the form of clay in retaining subterranean waters, and throwing them up as springs to the earth's surface; the geological history of common salt; the management of Dr. Wollaston's test for potash; the history of the supposed amalgam

of mercury with a metallic substance derived from ammonia or its elements; Dr. Wollaston's test for nitric acid; the undulatory theory of light, &c. &c.

Scarcely a page of the Chemical Catechism, it is observed by the Editor, has been reprinted without some emendation: references, for further information, to modern authorities, on all subjects of importance, have also been given, where necessary. Many of the notes of the former editions have been transferred to the text of the present, and some of the former "Additional Notes" have now been incorporated with the foot-notes or with the text.

In order to enable our readers to form an opinion of the manner in which Mr. Brayley has fulfilled his task, we proceed to extract some of his additions, several of which, we may remark, appear to have a value independent of that which they possess as parts of the Chemical Catechism. Of the style of his additions to the text we have an example in the Chapter on Caloric, in the subjoined reply to the observation and request,

"*You stated that the two processes of the Conduction and the Radiation of Caloric frequently act in union in effecting an equal diffusion of heat, or in producing the equilibrium of temperature:—Mention some familiar operation in which this union exists.*

"Not only are the processes of conduction aud radiation often united in the equal diffusion of heat, but that of reflection also, in many cases, is exerted in conjunction with them, for the same purpose. Thus in the common operation of heating dinner-plates in a plate-warmer before a fire, (which is only a case of the tendency to produce equilibrium of temperature, the plates being heated in consequence of the tendency of the fire to diffuse its caloric among the surrounding bodies,) all these processes are concerned. The plates are heated in three ways;—by radiation from the fire and from the plate-warmer itself, by reflection from the plate-warmer, and also by conduction and communication from it. Of the radiant heat which is received by the latter, a large portion is reflected upon the plates, especially if the inside be very bright and clean; another portion is absorbed, and this is gradually diffused by conduction throughout the utensil, and transferred to the plates resting upon it, as well as in part also reflected [radiated] upon them. In the former case, or in the passage of caloric from one body to another in contact with it, the caloric is said to be *communicated* by the one to the other, or to pass by *communication.* The same happens in many other familiar operations, and in those of the arts, as well as in the greater processes of nature; and that such must be the case in innumerable instances will appear evident, when the existence in all things around us of reflecting and radiating surfaces, of spaces occupied only by the air, through which radiation takes place, and of solid bodies through which conduction takes place, is considered."

When treating of ammonia, Mr. Parkes had stated in the Catechism itself, "If ammonia be decomposed in contact with mercury, by means of galvanism, ... an amalgam of the mercury with a metallic substance of a very uncommon nature may be procured from this alkali." And in a note he had added the following particulars:

"This experiment was first made in the year 1808 by the late Dr. Seebeck of Jena, and also about the same time by MM. Hisinger, Berzelius, and Pontin, of Stockholm. Mercury, by combination with about one twelve-thousandth part of its weight of new matter, is thus rendered a solid, and at the same time so expanded in volume that its specific gravity is reduced

from 13·5 to less than 3; while all its metallic characters of colour, lustre, opacity, and conducting powers, remain unimpaired."

Retaining both these statements, the Editor annexes the subjoined explanation:

"The history of this supposed amalgam of mercury with a metallic substance apparently derived from the ammonia or its elements, is still involved in obscurity; and as it is of considerable importance in a theoretical point of view, it cannot be passed over in silence at the present time. The above statements, both in the text and note, are agreeable to the results obtained by Sir H. Davy, who repeated the experiments of Berzelius and his coadjutors; but he discovered, also, a more simple method of obtaining the supposed amalgam, without the aid of galvanism. He found that when an amalgam of mercury with potassium (the metallic base of the alkali potash) is placed in contact with a solution of ammonia or with any moistened ammoniacal salt, it enlarges to eight or ten times its original bulk, becoming a soft solid, and acquiring the properties described in the preceding note. It was conceived both by Berzelius and Davy, that this singular result was produced by the union of new metallic matter with the mercury,—that it was truly an amalgam of a new metal, arising from the reduction of the ammonia or its elements to a metallic form; and they accordingly drew some important inferences from the fact of its production, respecting the intimate nature of ammonia as well as that of its constituents hydrogen and nitrogen. But neither of these chemists could succeed in separating the supposed new metal from the mercury, so as to exhibit it in an isolated state, which of course threw great doubt on the validity of their theoretical inferences; and the subject remained enveloped in mystery and difficulty. Some experiments not long since made by Mr. Daniell, however, afford strong grounds for believing, in the opinion of many chemists of the present day, that no metallization of the ammonia or its elements in reality takes place, and that the results obtained by Berzelius and Davy depend merely on a mechanical alteration of the arrangement of the particles of the mercury, and the entangling and retaining among them of small portions of ammonia or its constituent gases; and Mr. Daniell has obtained a substance bearing great resemblance to the supposed amalgam, without the presence of ammonia. Subsequent experiments by Mr. Brande lead to a similar conclusion. If, therefore, this view of the subject shall hereafter be fully confirmed, it will be proper to regard the statements upon it in the text and note above, not as affording any information respecting the composition of the alkali ammonia, but as describing merely a curious alteration in the mechanical condition of mercury, which can also be produced by other means. At the same time it must be admitted that absolutely decisive experiments on the supposed ammoniacal amalgam are still wanting; and it seems to be due to Berzelius and Davy that the question should be set at rest, by a series of delicate experiments instituted for the purpose. Those who wish for further information upon it, are referred to Davy's *Elem. Chem. Phil.* pp. 473, 481; Thomson's *Inorganic Chemistry*, vol. i. p. 146; and the *Journal of the Royal Institution*, vol. i. pp. 12, 251, and 548.

We have already stated that one of the novelties in this work is the history of that interesting class of bodies the vegeto-alkalies: after a general account of them, the specific properties and applications of the most important are detailed; and appended to a notice of the poisons deriving their effects from *Strychnia*, we find the following critical remarks on the two poisons of Java frequently confounded together by chemical writers under the appellation of *Upas*, which point out an important distinction:—

"The interest attached to the history of the *Bohun Upas*, or Poison Tree of Java, renders it important here to guard the student from a misapprehension respecting the substance in which its poisonous activity resides, which might arise from the manner in which the subject has been noticed alike by Dr. Henry, Mr. Brande, and Dr. Turner, when treating of the vegeto-alkalies, in their respective elementary works on chemistry. The original source of error is the confusion which exists in the popular knowledge of the two Javanese poisons, or rather its deficiency with respect to one of them. *Upas* simply means *poison*; and it is applied by the Javanese to two vegetable poisons, the *Upas antshar*, or *Bohun Upas*, derived from a tree, and the *Upas tshettik*, derived from a creeping shrub belonging to the genus *Strychnos*. But the word *Upas* in its popular reception in Europe is always taken to mean the *Bohun Upas*, respecting which so many marvellous relations have been promulgated; and hence, whenever that word is used, even when denoting in reality the *Tshettik*, it is supposed to refer to the first-mentioned poison. Pelletier and Caventou examined both these poisons, the former under the name of *Upas anthiar*, the latter under that of *Upas tieuté*; and as stated above, the activity of the former was found by them to reside in a peculiar vegeto-alkali, and that of the latter in *strychnia* itself. But Dr. Henry (*Elements*, vol. ii. p. 329) confounds the *Tshettik* with the *Bohun Upas*, when he states that strychnia appears, 'from the experiments of Pelletier and Caventou, to be separable, in a remarkably pure state, from the poison of the Upas tree.' Mr. Brande appears to do the same, when he remarks (*Manual*, vol. ii. p. 539) that 'the poison of the Upas tree' and the *woorara* 'affords a vegeto-alkaline base resembling strychnia;' for he must really mean, agreeably to the explanation just given, not the Upas tree, or *Bohun Upas*, but the Tshettik, or *Upas tieuté*; while the statement is likely to mislead in other respects, for the *Tshettik* affords strychnia itself, while the vegeto-alkali of the *woorara* is a distinct substance, resembling strychnia in some respects, but differing from it in others. Dr. Turner, by stating (*Elements*, p. 712) that Pelletier and Caventou have extracted strychnia 'from the Upas,' contributes to perpetuate the error,—as this remark, though not incorrect in itself (since the term *Upas* is applicable to both poisons,) will be taken by most readers as alluding to the *Bohun Upas* alone, which, as we have seen, does not contain strychnia; while as the *Tshettik* is not popularly known as a kind of *Upas*, it will be lost sight of altogether. In order to preclude errors of this kind, it would be desirable, in elementary works on chemistry and natural history, to confine the use of the term *Upas* to the *Upas antshar*, and always to prefix to it the word *Bohun* (signifying *tree*), which would denote it to refer to the well-known poison, of which *Bohun Upas* has become in Europe the popular name; and it would also be useful to notice particularly the existence of the more virulent *Tshettik*, which is at present scarcely known, except to those persons who are conversant with the natural history of Java."

The discussion of the Undulatory Theory of Light has often occupied our pages, of which the present and many preceding Numbers are examples: Mr. Brayley's sketch of the nature of light according to this theory (Mr. Parkes having previously explained its nature agreeably to the corpuscular hypothesis) is as follows:

"*What other view has been taken of the nature of light besides that which you have mentioned?*

"From the earliest periods two different views of this subject have been taken: one is that just stated; in the other, which owes its present form and perfection to the successive labours of Euler, the late Dr. Young, and the late M. Fresnel, the sensation of light is regarded to be imparted to the eye

by the undulations of a subtle fluid of extreme rarity and immense elasticity, in a manner exactly corresponding to that in which the undulations of the air impart the sensation of *sound* to the *ear*. This subtle fluid is conceived to pervade not only all the spaces between the sun and the planets, —so as to transmit to the latter the undulations impressed upon it by the action of the former,—but also the earth's atmosphere itself, and under various modifications, all the bodies, whether solid or fluid, of which the earth, so far as we know of it, consists; as water, and rocks, and minerals of all kinds. This hypothesis has very recently been supported by Professor Airy of Cambridge, by experimental evidence so demonstrative of its truth, that Professor B. Powell of Oxford, who is well qualified, by the attention which he also has paid to the subject, to pronounce an opinion upon it, has recently declared that the language of comparison between the two theories or hypotheses of the nature of light has ceased to be admissible; which is equivalent to a declaration that the undulatory hypothesis presents a true view of the nature of light; which thus appears to be, not a substance itself, but merely an affection of a substance, which has received the name of ether or the ethereal medium; as sound is not a substance itself, but merely an affection of a substance, which in this case is the air."

Professor Daniell, in his first paper on his new register-pyrometer, given (from the Philosophical Transactions for 1830) in the Phil. Mag. and Annals, N.S. vol. x. p. 191 *et seq.* has shown that had the degrees of Wedgwood's pyrometer been valued from the determination of the fusing point of iron by MM. Clement and Desormes, (a determination agreeing with that made by Mr. Daniell himself with his original pyrometer), the result would have better corresponded with the whole series of phænomena investigated. Instead of 130° Fahr. as fixed by the inventor, or 62°·5 as corrected by M. Guyton, those degrees would have been estimated at about 20° Fahr. In pursuance of this estimate, Mr. Brayley, when correcting the higher temperatures given in Mr. Parkes's "Table of the Effects of Heat" (p. 606-7), agreeably to Mr. Daniell's researches and to those of one or two other chemists, has added the corrected temperatures by Wedgwood's pyrometer also, which, as the indications of that instrument, however inexact, are still often referred to, will be useful to the student in correcting them. We subjoin the range of temperatures from Wedgwood's zero upwards.

	Fah.	Reau.	Cent.	Wedg.
" Iron red heat in day-light........................	1272	551	700	0
Enamel colours *burnt*, or *burnt-in**, on porcelain	1392	605	756	6
Bronze melts, copper $\frac{3}{4}$, tin $\frac{1}{4}$..............	1446	629	786	
——————, copper $\frac{7}{8}$, tin $\frac{1}{8}$..............	1534	668	835	
Diamond burns ?..............................	1552	676	845	14
" Orange heat (Prinsep)	1650	719	899	
Brass melts, copper $\frac{1}{2}$, zinc $\frac{1}{2}$..............	1672	730	911	
Brass melts, copper $\frac{3}{4}$, zinc $\frac{1}{4}$..............	1690	737	921	21
Bronze melts, copper $\frac{15}{16}$, tin $\frac{1}{16}$............	1750	794	955	
Silver melts....................................	1873	818	1023	28
Copper melts....................................	1996	862	1091	

* "This is a technical term used by enamellers, glass and porcelain painters, &c., to denote the fixing of the colours they employ, by means of vitrifaction, on the substances painted upon."

	Fah.	Reau.	Cent.	Wedg.
Gold melts	2016	860	1102	
Delft-ware fired	2072	967	1179	40
Cast-iron melts	2786	1224	1420	
Cream-coloured stone-ware fired	2992	1316	1645	86
Temperature of the maximum of expansion of platinum, being nearly the highest degree of heat attainable in a laboratory wind-furnace	3280	1444	1805	
Flint glass furnace, greatest heat?	3552	1253	1956	114
Soft iron melts, (according to Clement and Desormes, but in all probability an estimate considerably above the truth)	3945	1406	2118	

"The still higher temperatures, derived from the experiments of Mr. Wedgwood, which were here given in former editions of the Chemical Catechism, are now omitted; a comparison of them with the results obtained by Mr. Daniell, by means of his pyromoter, having shown that they cannot be relied upon. Some of the temperatures given in this Table above that of ignition, or 800°, must also be regarded as doubtful, and all of them must be regarded as approximative merely."

Among the additions to the Glossary, we find explanations of the following terms: "Anhydrous, Atmospheres (in a chemical sense), Atom, Capillary Tubes, Cleavage, 'Earth's Crust,' Excess, Free (acids, &c.), Hydrous, Isolated State, Isomeric Bodies, Isomorphism, Merorganization, Nascent, Plesiomorphism, Polymeric Bodies, Proximate constituents or elements, Real (acids, &c.) Ultimate constituents or elements, Zero, real," &c. &c.

From a careful review of its contents, we are induced to believe that the new edition of the Chemical Catechism will become as useful a medium of imparting the leading truths of Chemical Science, in its actual state of comparative advancement, as the earlier editions were found to be, in former stages of its progress;—of the justness of this opinion our readers will be enabled to form an estimate for themselves, from the analysis and extracts which we have now laid before them.

XXXVIII. *Proceedings of Learned Societies.*

LINNÆAN SOCIETY.

1835. Jan. 20.—READ a paper, by Thomas Taylor, M.D., F.L.S., entitled "*De Marchantieis.*" The author regards these plants as constituting from their higher development a distinct group from the *Hepaticæ*, with which they have been hitherto associated. The paper contains a description of twelve species, distributed into the following genera, namely,

1. *Marchantia*, Linn., of which *M. polymorpha* is the type.
2. *Fegatella*, Cæsalp. Raddi. Type of the genus *M. conica*, Linn.
3. *Lunularia*, Micheli. Type of the genus *M. cruciata*, Linn.
4. *Hygrophila*. Type of the genus *Marchantia irrigua*, Wilson in Hooker's Brit. Fl.; a new species discovered by the author and Mr. William Wilson in various parts of Ireland.

February 3.—Read "Observations on the Genus *Hosackia* and the American *Loti*." By George Bentham, Esq., F.L.S.

The author enumerates eleven species of this genus, the whole of which, except one from Mexico, are from California and the regions bordering on Columbia River, where they were discovered by Mr. Douglas. The *Lotus sericeus* of Pursh and several other species with solitary flowers, formerly referred by the author to *Hosackia*, he now considers as more naturally associating with *Lotus* than with that genus. His amended character of *Hosackia* is as follows: *Calyx* tubulosus vel subcampanulatus, 5-dentatus. *Vexilli unguis* a cæteris distans. *Alæ* vexillum subæquantes, patentes. *Carina* submutica. *Stylus* subrectus. *Stigma* capitatum. *Legumen* cylindraceum, apterum.

Herbæ (boreali-americanæ) *perennes*? Folia *impari-pinnata*. Stipulæ *scariosæ minutissimæ, vel folioli difformes*. Pedunculi *axillares, umbellatim pluriflori, folio florali, sæpiùs stipati*.

ROYAL ASTRONOMICAL SOCIETY.

November 14, 1834.—The Society met this evening, for the first time, in its new apartments in Somerset House, which have recently been appropriated to it by His Majesty's Government, through the interference and at the request of His Royal Highness the Duke of Sussex.

A vote of thanks was unanimously passed by the meeting, expressive of their sense of His Royal Highness's kind attention to the interests and welfare of the Society.

The following communications were then read:—Some account of the Astronomical Observations made by Dr. Edmund Halley, at the Royal Observatory at Greenwich. By F. Baily, Esq., President of the Society.

The author remarks, that although Dr. Halley was the Astronomer Royal for upwards of twenty years, yet that there are no accounts published of any of his observations, except the relation of the three following phænomena inserted in the Philosophical Transactions: viz. the solar eclipse on November 27, 1722; the transit of *Mercury* over the sun's disc on October 29, 1723; and the lunar eclipse on March 15, 1736. The rest exist in manuscript only, and have never yet been made public. They are contained in four small quarto volumes, deposited in the library of the Royal Observatory; and it has been a frequent subject of inquiry, both at home and abroad, as to the contents of these volumes, and the value of the observations.

These manuscripts are very badly, and sometimes rather confusedly written; especially in the early part of the series: there being numerous computations and much extraneous matter written on the same page with the observations, intermixed with and occasionally obliterating the more important figures: so that they cannot be so readily consulted with that ease and convenience, nor with that clearness and distinctness, which are desirable in works of this kind. Added to which, there is a constant risk of loss or damage by fire, or other accident, which ought not to exist in a document

of this importance. Under these circumstances, a representation of the case was laid before the Lords Commissioners of the Admiralty, who immediately ordered a fair copy of the observations to be made; and the same was by them presented to this Society in December 1832. It was in consequence of this gift that the author was induced to draw up the present memoir.

Mr. Baily first gives an account of the number and state of the instruments at the Observatory, the clocks, &c.: and it appears that for four years, at least, after Dr. Halley was appointed to his situation, he had only a 5½-feet transit instrument wherewith to carry on his observations. This is the first instrument of the kind erected there, and is described as "a curious telescopic instrument, fitted to an axis, and adjusted with screws to revolve in the plane of the meridian." It is evident, therefore, that Halley could at that period take nothing but transits. On the erection of the mural quadrant, however, in 1725, he was enabled also to take the zenith distances of the stars. He made observations likewise with two or three moveable telescopes with which he was furnished. And much confusion occurs, in the manuscript books, from the circumstance that the observations with all these different instruments are recorded exactly alike, so that there is nothing to guide the reader as to *which* instrument has been used in the observation.

The state of his clocks also is represented as being very confused and irregular; and the numerous stoppages they experienced, either in the act of being wound up, or from being suffered to run down, through absence or neglect, render it extremely difficult to deduce any very accurate results from the transit observations at such periods: an inconvenience which is felt, even to the very end of his labours.

Dr. Halley's observations were principally directed to the moon and planets: and with this object in view he usually observed such stars as were nearly on the same parallel of declination as those bodies, and differing from them very little in right ascension. Such observations therefore may, even now, be made available for determining the positions of those moveable bodies at those periods, and thus tend to perfect their theory. But with respect to any accurate information relative to the *absolute* position of the fixed stars, the author considers that it would be difficult, if not impossible, to obtain it: and that the most that can be expected from the observations would be the determination of the *relative* positions of some adjacent stars; neither does he consider that the observed stars are in sufficient number to warrant the expense and trouble of attempting such a measure.

After entering into an explanation of these and other modes of observing adopted by Dr. Halley, the author proceeds to notice some of the most remarkable phænomena recorded in the manuscript volumes. He states, that although there are many observations of the superior planets, yet none of them are very near the time of their opposition to the sun. There are also several observations of *Venus* and *Mercury*; but not a single observation of the eclipses of *Jupiter's*

satellites; neither has he been able to find more than one double observation of *Polaris*, above and below the pole, on the same day. There are eight occultations recorded; together with five solar, and four lunar eclipses. And amongst the usual observations there are three transits of the two singular stars 36 *Ophiuchi* and 30 *Scorpii*, remarkable for their great proper motion—journeying *together* through space, although upwards of 13′ distant from each other. Flamsteed has only one observation of 30 *Scorpii*, and Bradley did not observe it at all in right ascension. These observations, therefore, by Dr. Halley are so far interesting and satisfactory, that they confirm the uniformity in the motion of the two stars.

The non-publication of Halley's observations seems to have excited public notice even in his lifetime; and it appears that Sir Isaac Newton at length brought it under the notice of the Council of the Royal Society, who were at that time appointed to superintend such matters. Dr. Halley, who was present, excused himself by stating that, "there being many uses to be made of the said observations for forming a method for better ascertaining the longitude of places, and a great reward being appointed by Act of Parliament for discovering such methods, he had hitherto kept his observations in his own custody, that he might have time to finish the theory he designs to build upon them, before others might take the advantage of reaping the benefit of his labours." It was remarkable that this was the last meeting of the Royal Society at which Newton was present, as he died eighteen days after, in the 85th year of his age.

Mr. Baily closes his account by stating that the *copy* of the observations presented to the Society by the Lords Commissioners of the Admiralty had been examined and compared with the *original* by Dr. Lee, the Treasurer, and Lieut. Raper, one of the Council of the Society: a laborious task which they have executed with great care and attention. In the execution of this troublesome undertaking they discovered numerous errors of the amanuensis, which have since been carefully corrected: so that there is now every reason to believe that the transcript is a faithful and accurate copy of the original.

A short communication was read from Professor Schumacher to Mr. Baily, announcing that two comets had been discovered by a pupil of M. Dumouchel, of the Collegio Romano at Rome. "As, however," it is observed in the Monthly Notices of the Society, "no very precise circumstances are given whereby the public might be enabled to judge of the reality of the discovery, it would not be fair to M. Dumouchel to make any formal announcement on the subject.

Mr. Riddle communicated an account of a large meteor (apparently about the size of the moon) which was seen by Mr. Haggard, and Mr. Haggard, jun., at Blackheath, between twelve and one o'clock on the night of Wednesday, October 20. Mr. Haggard describes it as resembling a ball from a Roman candle in colour.

ZOOLOGICAL SOCIETY.

September 9, 1834.—A letter was read, addressed to the Secretary by Dr. E. Rüppell, and dated Frankfort, August 10, 1834. It was

accompanied by specimens of *Magilus antiquus*, Rupp., including both the shell and the animal, and of the shell and animal of a new genus of *Pectinibranchiated Gasteropodous Mollusca.* The latter was accompanied by a description by Dr. Rüppell, who characterizes it, as follows, under the designation of *Leptoconchus.*

Testa tenuis, pellucida, subglobosa, spirâ depressâ, subobsoletâ: *aperturâ* magnâ, subovali, extremitatibus in contrarium versis, marginibus haud coalitis, dèxtro tenui anticè subexpanso: *columellâ* nullâ, *umbilico* nullo, anticè truncatâ, contortâ.

Animal proboscide elongato, retractili: *tentaculis* duobus, complanatis, trigonis, internè ad basin coalitis, externè in medio oculos gerentibus: *pede* mediocri, *operculo* nullo: *pallio* ad marginem circulari, haud appendiculato, ad latus sinistrum subproducto: *foramine branchiali* submagno.

The colour of the shell which constitutes the type of this new genus is constantly a slightly sordid milk-white. It is sulcated externally by numerous longitudinal undulated closely set lines, the outer whorls encroaching on the spire of the earlier ones so as almost to obliterate it.

Length of the adult shell, 14¾ lines; greatest breadth, 12½; length of the young shell, 7½; breadth, 6.

Individuals of all ages have the shell thin and fragile, and constantly occur imbedded in the calcareous mass of polypes, having a communication with the sea by only a moderate opening. They are found in the Red Sea, and are most frequently met with in *Meandrina Phrygia.*

To distinguish the shell of *Leptoconchus* from that of *Magilus* it is sufficient to observe that in the latter the two margins of the aperture are always united, while in the former genus they are always disunited. The animals are distinguished by the possession and the want of an *operculum*, and by the difference in the *proboscis*; the *siphon* of *Magilus*, moreover, does not occur in *Leptoconchus.*

Dr. Rüppell suggests that the systematic place which should be assigned to this genus is near the *Ianthinæ.* The number of the *tentacula*, the oral *proboscis*, the mantle destitute of *siphon*, the pectinated *branchiæ* composed of closely heaped pyramids, and the absence of *operculum*, are so many marks of affinity; to which may be added some of the characters of the shell: but he states himself to be perfectly aware that the difference between the habitations of these genera is so wide as to afford no confirmation of the correctness of this approximation.

A letter was read, addressed to the Secretary by B. H. Hodgson, Esq., Corr. Memb. Z.S., and dated Nepal, March 4, 1834.

It commences by remarking on the difficulty experienced by Zoologists in the determination of distinctive marks adequate for the separation of the genera *Antilope*, *Capra*, and *Ovis*; and then refers to the instances in which the writer has shown that the character of *Antilope* founded on the presumed absence of cavities in the cores of the horns connected with the frontal sinuses is incorrect. The value of the characters which are generally admitted by authors as distinguishing between the genera *Capra* and *Ovis* may, he con-

ceives, be tested by a comparison of the wild race of either genus which belongs to the Himalaya.

"For the last year," Mr. Hodgson proceeds, "I have had alive in my garden a splendid specimen of the mature male of each; and I have frequently compared them together in all respects of manners and of structure. As the *Goat* in question, as well as the *Sheep*, is new, I will begin with a synoptical description of the two, and then proceed to notice the points of difference and of agreement existing between them.

Tribe Capridæ, *H. Smith.*

Genus Capra, *Linn.*

Species *Capra Jhâral.*—The *Jhâral* of the Nepalese.

"Affined to the *Alpine Ægagri* and to *Capra Jemlaica.* Adult male 50 inches long from snout to rump, and 33 high. Head finely formed and full of beauty and expression, clad in close short hair, and without the least vestige of a beard. Facial line straight. Ears small, narrow, erect, rounded at the tips, and striated. Eye lively. Between the *nares* a black moist skin. *Nares* themselves short and wide. Knees and *sternum* callous. Tail short, depressed, wholly nude below. Animal of compact powerful make, with a sparish, short, and bowed neck; deep barrel and chest; longish, very strong, and rigid limbs, supported on perpendicular pasterns, and high compact hoofs: false hoofs conic and considerably developed. Attitude of rest gathered and firm, with the head moderately raised, and the back sub-arched. Shoulders decidedly higher than the croup. Fore quarters superb, and wholly invested in a long, flowing, straight, lion-like mane, somewhat feathered vertically from the crown of the withers, and sweeping down below the knees. Hind quarters poor and porcine, much sloped off from the croup to the tail, and the skin much constricted between the hams behind. Fur of two sorts: the outer, hair of moderate harshness, neither wiry nor brittle, straight, and applied to the skin, but erigible under excitement, and of unequal lengths and colours; the inner, soft and woolly, as abundant as in the *Wild Sheep* and finer, of one length and colour. Horns 9 inches long, inserted obliquely on the crest of the frontals, and touching at the base with their anterior edges; subcompressed, subtriangular, and uniformly wrinkled across, except near the tips, where they are rounded and smooth, keeled and sharpened towards the points, obtusely rounded behind; the edge of the keel neither nodose nor undulated, but smooth, or evanescently marked by the transverse wrinkles of the horns. The horns are divergent, simply recurved, and directed more upwards than backwards.

"Colour of the animal a saturate brown superficially, but internally hoary blue, and the mane, for the most part, wholly of that hue. Fore arms, lower part of hams, and backs of the legs, rusty. Entire fronts of the limbs, and whole face and cheeks, black-brown; the dark colour on the two last parts divided by a longitudinal line of pale rufous; and another before the eye, shorter. Lips and chin hoary, with a blackish patch on either side below the gape. Tip of tail and of ears blackish. Tongue and palate, and nude skin of lips

and muzzle, black. *Iris* darkish red hazel. Odour very powerful in the mature male at certain times.

"Found in the wild state in the Kachâr region of Nepal, in small flocks or solitarily. Is bold, capricious, wanton, eminently scansorial, pugnacious, and easily tamed and acclimatised [acclimated] in foreign parts.

"REMARKS. *Jhâral* is closely affined by the character of the horns to the *Alpine Ægagri,* and still more nearly, in other respects, to *Capra Jemlaica.* It differs from the former by the less volume of the horns, by their smooth anterior edge, and by the absence of the beard; from the latter, by the horns being much less compressed, not turned inwards at the points, nor nodose. *Jhâral* breeds with the *domestic Goat,* and more nearly resembles the ordinary types of the tame races than any wild species yet discovered.

Genus OVIS, *Linn.*

"Species *Ovis Nâhoŏr*, Mihi.—The *Nâhoŏr* of the Nepalese. New? Variety of *Ovis Musmon*?

"Closely affined to *Ovis Musmon,* of which it is probably only a variety. Adult male 48 inches from snout to rump, and 32 high. Head coarse and expressionless, clad entirely in close short hair, without beard on the chin or throat, or any semblance of mane. Chaffron considerably arched. Ears medial, narrow, erect, pointed, striated. Eye dull. Moist space between the *nares* evanescent. *Nares* narrow and long. Knees and *sternum* callous. Tail medial, cylindrico-depressed, only half nude below. Structure moderately compact, not remarkable for power. Neck sparish, bowed, with a considerable dip from the crown of the shoulders. Limbs longish, firm, but slender, not remarkable for rigidity, and supported on lax pasterns, and on hoofs lower and less compact than the *Goat's*; false hoofs mere callosities. Attitude of rest less gathered and firm, with the head lower, and the back straight. Shoulders decidedly lower than croup. Fore quarters not more massive than the hind, nor the extremities stronger. Fur of two sorts: the outer, hair of a harsh, brittle, quill-like character, serpentined internally, with the salient bows of one hair fitting into the resilient bends of another; externally straight, porrect from the skin, and very abundant; of medial uniform length all over the body; the inner coat, soft and woolly, rather spare, and not more abundant than in the *Goat.* Horns 22 inches along the curve, inserted high above the orbits on the crown of the forehead, touching nearly at the base with their whole depth, and carrying the frontal bones very high up between them, the parietals being depressed in an equal degree*. The horns diverge greatly, but can scarcely be said to be *spirally* turned. They are first directed upwards considerably before the facial line, and then sweep downwards with a bold curve, the points again being recurved

* The *Goat's* skull has the same form, but less strikingly developed; and unless I am mistaken, this form of the skull would afford a just and general mark to separate *Ovis* and *Capra* from *Cervus* and *Antilope.* There is a gradation of characters in this respect among the *Antelopes* tending to the *Caprine* type in their general structure.

upwards and inwards. They are uncompressed, triangular, broadly convexed to the front, and cultrated to the back. Their anterior face is the widest, and is presented almost directly forwards: their lateral faces, which are rectilinear, have an oblique aspect, and unite in an acutish angle at the back. They are transversely wrinkled, except near the tips, which are round and smooth.

"The colour of the animal is a pale slaty blue, obscured with earthy brown, in summer overlaid with a rufous tint. Head below, and inside of the limbs and hams, yellowish white. Edge of the buttocks behind and of the tail pure white. Face and fronts of the entire limbs and chest blackish. Bands on the flanks the same, and also the tip of the tail. Tongue and palate dark. Eye yellow hazel. No odour.

"Is found in the wild state in the Kachâr region of Nepal, north of the *Jhâral*, amid the glaciers of the Himalaya, and both on the Indian and Tibetan sides of the snowy crests of that range: is sufficiently bold and scandent, but far less pugnacious, capricious, and curious than the *Jhâral*. Much less easily acclimatised in foreign parts than he is, in confinement more resigned and apathetic, and has none of the *Jhâral's* propensity to bark trees with his horns, and to feed upon that bark and upon young shoots and aromatic herbs. I have tried in vain to make the *Nâhoŏr* breed with tame *Sheep*; because he will not copulate with them. The female of the species has the chaffron straight; and the horns short, erect, subrecurved, and greatly depressed. The young want, at first, the marks on the limbs and flanks, and their nose is straight.

"Remarks. Differs from *Ovis Musmon*, to which it is closely allied, by the decided double flexure of the horns, their presence in the females, and the want of a tuft beneath the throat.

"Having now completed the descriptions of the *Wild Goat* and the *Wild Sheep*, I shall proceed to the exhibition of the points of difference and of resemblance between the two, beginning with the former.

Goat.	*Sheep.*
Whole structure stronger and more compact.	Less so.
Limbs thicker and more rigid.	Feebler and more slender.
Hoofs higher and more compact.	Lower and less so.
False hoofs well developed.	Evanescent.
Head smaller and finer.	Larger and heavier.
Facial line straight.	Chaffron arched.
Ears shorter and rounded.	Longer and pointed.
Tail short, flat, nude below.	Longer, less depressed, and half nude only.
Withers higher than croup.	Croup higher.
Fore legs stronger than hind.	Fore and hind equal.
Croup sloped off.	Not so.
Odorous.	Not so.
Nose moister, and *nares* short and wide.	Less moist, longer, and narrower.

Goat.	*Sheep.*
Horns of medial size, keeled, and turned upwards.	Horns very large, not keeled, and turned to the sides.
Eye darker and keener.	Paler and duller.
Hair long and unequal.	Short and equal.
Back arched.	Back straight.
Bears change of climate well.	Bears it ill.
Is eminently curious, capricious, and confident.	Is incurious, staid, and timid.
Barks trees with its horns, feeding on the peel, and on aromatic herbs.	Does not bark trees, and is less addicted to aromatics.
In fighting rears itself on its hind legs and lets the weight of its body fall on the adversary.	In fighting runs a-tilt, adding the force of impulse to that of weight.

"The *Goat* and *Sheep* have in common, hair and wool; no beard; no suborbital sinuses; evanescent muzzle; no inguinal pores; horns in contact at the top of the head; knees and *sternum* callous; angular and transversely wrinkled horns; striated ears; two teats only in the females; horns in both sexes; and, lastly, incisors of precisely the same form.

"Of the various diagnostics, then, proposed by Col. Hamilton Smith, it would seem that the following only can be perfectly relied on to separate *Ovis* from *Capra*: slender limbs; longer pointed ears; chaffron arched; *nares* long and oblique; very voluminous horns, turned laterally with double flexures. I should add myself, the strong and invariable distinction,—males not odorous,—as opposed to the males odorous of the genus *Capra*. But, after all, there are no physical distinctions at all equivalent to the moral ones so finely and truly delineated by Buffon, and which, notwithstanding what Col. H. Smith urges in favour of the courage and activity of *Sheep*, will, for ever, continue to be recognised as the only essential diagnostics of the two genera."

September 23, 1834.—A letter was read, addressed to the Secretary by John Hearne, Esq., Corr. Memb. Z.S., and dated Port au Prince, July 16, 1834. It accompanied a present of "an *Alligator* from the river Artiboniti," which is referrible to the *Crocodilus acutus*, Cuv.; and of some *Doves*. These are the *little Ground Dove* or *Ortolan* of the English residents in Hayti, *Columba passerina*, Linn.; and the *red-legged Partridge*, as it is called in that island, *Col. mystacea*, Temm. Mr. Hearne adverts to some other animals which he has observed in Hayti, and expresses his hopes of succeeding in bringing or sending them to England.

The Secretary adverted to some other animals lately added to the Menagerie, and which he regarded as interesting either in a scientific point of view, or on account of their not having been previously contained in the collection. They included the *silky Monkey, Midas Rosalia*, Geoff., of which a specimen has recently been presented by T. Manton, Esq.; the *Javanese Ichneumon, Herpestes Javanicus*,

Geoff.; the *African Moufflon, Ovis Tragelaphus*, Geoff., presented by Sir Thomas Reade, His Majesty's Consul-General at Tunis; and a remarkably darkly coloured variety of the *European Bear, Ursus Arctos*, Linn., presented by R. H. Beaumont, Esq.

Among the *Birds* there have been added a pair of the *pied Pigeon* of New Holland, *Columba armillaris*, Temm.; a pair of the *Capercailzie* or *Cock of the Woods, Tetrao Urogallus*, Linn., obtained from Norway and presented to the Society by J. H. Pelly, jun., Esq.; a pair of the *Buffonian Touraco, Corythaix Buffonii*, Le Vaill.; and a specimen of the *naked-legged Owl* of the Indian Islands, *Ketupa Javanensis*, Less., (*Strix Ketupu*, Horsf.,) presented by James Harby, Esq., and stated to have been brought from Manilla.

Among the *Reptiles* there have recently been added an interesting collection of *Tortoises* from China, presented by John Russel Reeves, Esq., of Canton, and including specimens of the *three-banded Box-Tortoise, Cistuda trifasciata*, Gray; of *Spengler's Terrapin, Geoemyda Spengleri*, Gray, (*Testudo Spengleri*, Walb.); (see our last number, p. 152); of the *Emys Sinensis, Em. Reevesii*, and *Em. Bealii*, all lately described by Mr. Gray; and also of the *Platysternon megacephalum*, Gray. A *Crocodile* apparently referrible to the *Crocodilus cataphractus*, Cuv., is also at present living in the Menagerie: its nuchal plates constitute a series continuous with those of the back, but consist of only four rows instead of five, the number existing in the individual on which the species was originally founded. The specimen is stated to have been brought from Fernando Po.

Mr. Ogilby called the attention of the Meeting to a specimen of an *Irish Otter*, which he at the same time presented to the Society in the name of Miss Anna Moody of the Roe Mills near Newtown Lemavaddy, by whom it was preserved and mounted. On account of the intensity of its colouring, which approaches nearly to black both on the upper and under surface; of the less extent of the pale colour beneath the throat as compared with the *common Otter, Lutra vulgaris*, Linn., as it exists in England; and of some difference in the size of the ears and in the proportions of other parts; Mr. Ogilby has long considered the *Irish Otter* as constituting a distinct species; and he feels strengthened in this view of the subject by the peculiarity of its habitation and manners. It is, in fact, to a considerable extent a marine animal, being found chiefly along the coast of the county of Antrim, living in hollows and caverns formed by the scattered masses of the basaltic columns of that coast, and constantly betaking itself to the sea when alarmed or hunted. It feeds chiefly on the salmon, and as it is consequently injurious to the fishery, a premium is paid for its destruction; and there are many persons who make a profession of hunting it, earning a livelihood by the reward paid for it and by disposing of its skin. Mr. Ogilby stated his intention of comparing it minutely with the *common Otter* as soon as he should be enabled to do so by the possession of entire subjects, and especially of attending to the comparison of the osteological structures. He added that he proposed to designate it, provisionally, as the *Lutra Roensis*, in honour of the lady by whom it was presented.

Mr. Owen read a "Description of a recent *Clavagella*," founded on the examination of an individual brought home by Mr. Cuming and imbedded in siliceous grit. The portion of rock contained the whole of the expanded cavity excavated for the abode of the animal, together with the fixed valve of its shell and about an inch of its calcareous tube: the loose smaller valve was detached from the soft parts. Mr. Owen describes in detail the fixed valve, which corresponds to the left side of the animal's body; the attachment to it of the adductor muscles, two in number; its passage into the calcareous tube by a continuance of the shelly substance; the tube itself, which communicates with the posterior part of the chamber next the side which corresponds with the ventral surface of the animal; and the free valve. He regards it as probable that the animal of this species, having penetrated into the rock for a certain distance, then becomes stationary, and limits its operations to enlarging its chamber to the extent required for the development of its ovary: this enlargement takes place in the dorsal, dextral, and anterior directions.

The soft parts of *Clavagella* form an irregularly quadrate mass, convex anteriorly, rather flattened at the sides, and slightly narrowing towards the posterior end, from which the smooth rounded *siphon* is continued. This contains the anal and branchial canals, which are separated by a strong muscular *septum*, but do not project as distinct tubes: in this respect *Clavagella* agrees with *Gastrochæna* and *Aspergillum*. The mantle is a closed sac, having only an opening for the passage of the *siphon* and a small slit at the opposite end for the passage of a rudimentary foot: the use of this slit in *Clavagella* is obviously different from that assigned by M. Rüppell to the corresponding structure in *Aspergillum*.

Mr. Owen describes the mantle and its structure; the *siphon*; and the thick mass of muscular fibres at the anterior part of the mantle, which forms probably one of the principal instruments in the work of excavation: he also notices the great development, as compared with the size of the animal, of the adductor muscles. He then proceeds to the *viscera*, which generally agree with the typical structure in other *Bivalves*. The digestive system, which accords with that which is usual in *Acephalous Mollusca*, is described; as are also the respiratory and circulating systems, the principal nervous *ganglia*, and the ovary.

The paper was accompanied by drawings illustrative of the several structures described in it.

The specimen described belongs to the species termed by Mr. Broderip *Clavagella lata*.

XXXIX. *Intelligence and Miscellaneous Articles.*

MR. STURGEON ON AN AURORA BOREALIS SEEN AT WOOLWICH, ON DECEMBER 22, 1834.

A BEAUTIFUL Aurora Borealis was seen from this place last night. I was on Woolwich Common when I first saw it, then ex-

actly six o'clock. It consisted of several groups of vertical beams of pale yellowish light on both sides of the north star, extending nearly to equal distances in the western and eastern directions. These beams presented the strongest light at their bases, and grew gradually fainter, to their superior extremities, where they softened and gently glided into the most attenuated light, and were lost at various altitudes, some of which were near to the zenith. These streamers soon faded, and gave place to a few straggling vertical coruscations, displayed in various parts of the northern sky, which in their turn were again succeeded by the finest streamers I ever beheld. It was now five minutes past six. These splendid streamers were of the same tint as the former, and extended from the black nucleus near the horizon to the zenith in nearly the same manner; but the refulgence of these far exceeded that of the former. These streamers consisted principally of two parallel groups, one on each side of the north, and with some considerable distance between them. Smaller streamers were, however, playing in the intermediate space, and also on their outer horizontal skirts. The horizontal boundaries of the aurora, at this time, seemed to be the Milky Way on the west, and near to the planet Mars on the east. From this time the aurora gradually diminished in splendour, and about seven was nearly lost; it occasionally, however, brightened with a few faint flashing momentary streamers till between ten and eleven, at which time I discontinued my observations.

During the display of the fine streamers, which first presented themselves about five minutes past six, I hurried home to adjust a magnetic needle. It was about half-past six before I had my magnetic apparatus fit for observation, and the splendour of the aurora had now passed its meridian. I diligently watched the needle and the aurora till half-past ten, but observed nothing in the motions of the former that could possibly be attributed to the influence of the latter.

From the brilliancy of the aurora at six o'clock, I imagine that it was exhibited at a much earlier period of the evening, but I have had no opportunity of ascertaining the fact from persons likely to have seen it. I think it is likely that the aurora was very fine in Scotland, and perhaps in higher north latitudes, after seven o'clock, perhaps till nine or ten.

Artillery Place, Woolwich, Dec. 23, 1834. W. STURGEON.

P.S. This aurora appeared to have no particular respect for the magnetic north: it was nearly, if not exactly, bisected by the *true meridian* during the whole of the time I observed it.

MR. GILL ON THE STRUCTURE OF THE FIBRES OF FLAX AND COTTON, IN REFERENCE TO THE OBSERVATIONS OF MR. BAUER.

To the Editors of the Philosophical Magazine and Journal of Science.

Gentlemen,

I felt myself much interested in the perusal of a late article in your valuable work, by Mr. Thomson, on the *Mummy Cloth*;

proving, by Mr. Bauer's microscopic delineations, that, instead of it being made of *cotton*, it is, in fact, *linen*. I had long employed the microscope for the purpose of distinguishing the difference between linen and cotton, and in most of the statements I concur. I must, however, disagree with Mr. Bauer on the point that the fibres of flax are *cellular*; on the contrary, when they are perfectly freed from the cross fibres by which they are held together in their natural state, (which was most completely effected by the late Mr. Lee), they are each found to be composed of *one undivided cylindrical fibre*, extending from the root to where they are united to the leaves of the plant. I have specimens of flax so treated by Mr. Lee, and which, from their beautiful glossiness, have frequently been mistaken for silk.

I have not found that the flat fibres of cotton are *uniformly twisted*, but only occasionally so, and in different degrees; in fact, many are not twisted at all.

I am glad that the microscope is at length likely to find its due estimation; and hope it will now be more frequently employed in showing us things as they really are. I am, Gentlemen,

With much respect, your most obedient servant,

Savoy Depôt of Practical Science, Thomas Gill,
125, Central Strand, London, Jan. 16, 1835. Advising Engineer.

ON PROFESSOR MITCHELL'S METHOD OF PREPARING CARBONIC OXIDE. BY DR. GALE.

In vol. v., p. 391, of the London and Edinburgh Philosophical Magazine, we have inserted Dr. Mitchell's method of preparing carbonic oxide free from carbonic acid. We have since found that several of Dr. M.'s statements are erroneous, and intended to have noticed them; instead of this we copy the following observations by Dr. Gale, Professor of Chemistry in New York, contained in Silliman's Journal for October last.

"Having received No. 2. of Vol. XXV. of this Journal, containing Professor Mitchell's paper on a new process for preparing carbonic oxide, about the time I was to lecture on that subject before my class in the College of Pharmacy, I adopted Prof. M.'s plan, and followed his directions as nearly as possible, but much to my discomfiture found the gas obtained was perfectly incombustible: but I should here state, that it was used immediately after preparation. As gases will sometimes burn from a large orifice when they will not from a smaller one, I varied the size of the aperture, but all to no purpose. I then collected more gas, with 'heat duly moderated,' and preserved only the first and last portions, but did not succeed in causing it to burn from an orifice. I then threw up, by means of a syringe, some caustic potash into the receiver containing the gas; a rapid absorption took place, amounting to nearly half the original quantity, and the remainder was sufficiently pure carbonic oxide. I also ascertained, that if the gas, when procured, be allowed to stand over cold water, and especially in broad and shallow receivers, for two or three hours, so much of the carbonic acid is absorbed

that the remaining gas will burn with its ordinary appearance. The same remark will apply to carbonic oxide prepared by any of the ordinary methods described in the books. Indeed, I am constantly in the habit of preparing the gas in the morning, when it is to be used in the afternoon, and thus avoid the occasion of using any alkali.

"Although from the above experiments I was quite satisfied that carbonic acid is always produced in the above-mentioned experiments, yet, that I might be able to speak with perfect confidence, I was induced to make a complete analysis of the gas obtained after Dr. Mitchell's plan. Taking a given weight of the oxalate of ammonia, and the proportion directed of sulphuric acid, I collected the whole gas evolved from the materials over mercury, that none should be absorbed during the operation. One hundred equal parts having been set aside for examination, pure liquid potassa was thrown up by means of a syringe, and the vessel agitated until no more absorption took place, when fifty parts of the gas had disappeared. The residual gas, on being detonated with oxygen, was found to be nearly pure carbonic oxide. In order to ascertain whether the gas differed in its qualities at different stages of the process, I collected portions of it at regular intervals, throughout the operation, and subjected them to careful examination. The result of these experiments was pretty uniform, not varying in any case two per cent. from fifty measures of each gas; and hence I infer, that the oxalate of ammonia, treated as above, for obtaining carbonic oxide, yields the same products as the binoxalate of potassa or oxalic acid, treated according to the methods described in the books.

"Professor Mitchell states, that 'on examining the residuary matter left in the retort, it is found to be strong sulphuric acid.' I must confess, I am at a loss to know in what way he made an examination, to arrive at such a conclusion, unless it be that he used more than 'one or two drachms of sulphuric acid,' for in each case in which I examined the residue, where an ounce of the oxalate and two drachms of acid were used, I found crystals in the retort, after the materials had cooled, answering in every respect to the acid sulphate of ammonia. If the quantity of sulphuric acid be increased to four or five drachms, and the heat be stopped a little before the gas ceases to come over, the acid will then hold the sulphate in solution and exhibit to the eye an appearance of sulphuric acid; but a single and very simple experiment, namely, the evaporation of a few drops of the liquid on a platinum or glass capsule, until a part of the acid is expelled, will indicate the presence of some salt, and that, on examination, will be found as above mentioned. That ammonia should escape from the retort, in a free state, while it is in contact with a large excess of free sulphuric acid, and then combine with the carbonic acid resulting from the decomposition of the oxalic acid, appears to me unphilosophical, and is disproved by experiment, for we recover the whole, or very nearly all the ammonia in combination with sulphuric acid."

CARBONATE OF STRONTIA DISCOVERED IN THE UNITED STATES.

The following letter on this subject is contained in Silliman's Journal for October last.

"I embrace an early opportunity of stating, through the medium of the Journal of Science, the discovery of the carbonate of strontia in this country. So far as my knowledge extends, this mineral has not, until the present time, been observed in the limits of the United States, and it is even considered rare in Europe. This fact makes it peculiarly interesting to our mineralogists. Perhaps I ought to make a reserve in pronouncing it pure carbonate of strontia, as the mineral may contain other elements besides carbonic acid and strontia. The following are some of its most interesting characters.

"Colour, nearly pure white; sometimes tinged yellowish on the surface. Lustre, vitreous; fibrous varieties, pearly. Translucent... opake. Brittle, and easily reduced to a powder. Hardness = 3·5, of the scale of Mohs. Specific gravity, undetermined. Streak, white. Cleavage, apparently parallel to the plane of a rhombic prism. The crystallization is too imperfect to admit of measurement.

"Before the blowpipe it is infusible, but with a strong heat an imperfectly friable, white mass is formed, which has an acrid alkaline taste. Colour of the flame, red or reddish purple.

"In muriatic acid it dissolves, with an active effervescence, accompanied with the disengagement of carbonic acid. Solution incomplete in cold muriatic acid. The muriatic solution, on the addition of alcohol, burns with a fine carmine red flame. From this solution sulphuric acid throws down a white precipitate.

"The varieties of this substance are mostly compound. The most perfect consist of stellated groups, or rather of imperfect individuals diverging from several centres, forming masses of different sizes. On one partially decomposed specimen, I observed a few small but regular six-sided prisms. In all other cases, the crystallization is too confused to permit the determination of the precise forms, or their dimensions. Some pieces, which evidently contain carbonate of strontia, resemble, externally, its congener, the sulphate; that is, they are tinged bluish, and present a structure both laminated and fibrous.

"I conjecture that some of the specimens are the baro-strontianite of Traill. Others seem to be strontia, combined with carbonate of lime.

"The locality of this mineral, or family of minerals, is Scoharie, New York, in the vicinity of Ball's Cave, which has already furnished so many fine things for our cabinets.

"I hope, ere long, to furnish a more particular account of the varieties mentioned in this communication.

"William's College, Aug. 15, 1834. EBENEZER EMMONS."

SEPARATION OF SOME METALLIC OXIDES.

M. Person proposes to separate the oxides of cobalt and nickel in the following manner: Paraphosphoric acid is to be added to a

nitric or muriatic solution of these oxides sufficient to saturate them; ammonia is to be poured into the solution, which occasions a precipitate, which is redissolved by excess of ammonia. The liquor assumes a greyish blue or violet tint, according to the proportions of the two oxides. Exposed to the air in an open vessel, this solution loses the excess of ammonia, and becomes turbid. The deposit formed consists of a double paraphosphate of nickel and ammonia, at first of a greyish colour, and then of a fine green. When the liquor becomes clear, the solution is of a fine rose colour. If it contains no nickel, it may be evaporated without becoming turbid, to the consistence of a syrup. The two salts being thus isolated, the paraphosphoric acid is to be separated either by the hydrosulphuret of ammonia or by carbonate of soda.

SEPARATION OF OXIDE OF CADMIUM AND OXIDE OF BISMUTH.

Paraphosphate of bismuth is insoluble in solution of ammonia, while paraphosphate of cadmium dissolves readily in it as long as there is excess of ammonia. If, then, these two oxides are dissolved by nitric acid and paraphosphoric acid be poured into the solution, all the bismuth is precipitated. After having washed the precipitate with solution of ammonia, all the cadmium will be removed; and it only remains to separate the oxides from the paraphosphoric acid.

This method may also be applied to the separation of the oxides of lead and mercury, the latter forming a soluble salt with the paraphosphoric acid and ammonia, whilst the oxide of lead forms an insoluble one.

The paraphosphoric acid employed by M. Person is obtained by calcining pure phosphate of ammonia.

Separation of oxide of uranium from the oxides of cobalt, nickel, and zinc.—Oxide of uranium may be completely separated from these three oxides, by using subacetate of lead; for a solution of this salt poured into a solution of nitrate of uranium, cobalt, nickel, and zinc, forms a precipitate of uranate of lead, which is completely insoluble in excess of a solution of subacetate of lead; whereas, under the same circumstances, the insoluble compounds of oxide of cobalt, of nickel, and of zinc with lead, dissolve very readily in excess of the subacetate. It was in this way that Mr. Person discovered cobalt in combination with uranium, under circumstances in which other methods would be unavailable.—*Ann. de Chim. et de Phys.*, t. lvi. p. 333.

ACTION OF MURIATE OF AMMONIA ON CERTAIN SULPHATES.

M. Vogel finds when equal bulks of strong solutions of muriate of ammonia and protosulphate of iron are mixed, small transparent crystals of a bright yellow colour are formed in twenty-four hours. These crystals are very hard, and much less soluble in water than sulphate of iron.

When these crystals are heated by a spirit-lamp in a glass, they swell a little without fusing; they become of a dull white and opake; water evaporates, and afterwards ammonia and sulphate of ammonia.

When strong sulphuric acid is poured upon these crystals, they yield water to it and become opake, without effervescing.

The aqueous solution of these crystals is colourless, and contains protoxide of iron. Nitrate of silver does not throw down any chloride; but after some time metallic silver is precipitated. There is therefore no muriatic acid in these crystals, and they act like sulphate of iron and ammonia.

As these crystals contain no muriatic acid, the question is, What has become of that portion which the muriate of ammonia contained? This acid was not expelled, and the mother-water did not redden litmus paper more than the sulphate would have done; nor was any muriate of iron formed; but rather a double salt, in which muriatic acid was neutralized by ammonia and by protoxide of iron; and this salt crystallizes by evaporation in transparent very hard octahedrons of a yellow colour. This salt is not deliquescent, and when sulphuric acid is added to it, muriatic acid gas is evolved. When heated in a glass tube, muriate of ammonia sublimes, and oxide of iron remains. It is very soluble in water, but insoluble in alcohol, and consists of a neutral combination of muriatic acid, oxide of iron, and ammonia.

The solution of sulphate of copper becomes green when mixed with one of muriate of ammonia, in equal volumes, in a close vessel, and in half an hour a bluish white salt is formed, and in twenty-four hours the crystals increase considerably in volume. They are transparent, but lose this transparency and their water of crystallization in dry air. Sulphuric acid occasions no effervescence in them, nor does nitrate of silver render a solution turbid; they therefore contain no muriatic acid: they are soluble in one part and a half of boiling water, and the solution crystallizes on cooling. They have the properties of a neutral compound of sulphuric acid, peroxide of copper, and ammonia. The mother-water decanted and evaporated gives crystals of a bright green, which are unalterable in the air; they consist of muriatic acid, neutralized with oxide of copper and ammonia.

The mixed concentrated solutions of sulphate of manganese and muriate of ammonia, give no crystals after several days, but by evaporation crystals are obtained on cooling. These crystals are not like either sulphate of manganese or muriate of ammonia; they are hard, of a clear yellowish white, and contain no muriatic acid, At between 140° and 158° Fahr. they lose their water of crystallization and become opake: when heated in a glass tube, water and sulphate of ammonia are volatilized.

It appears, then, that the sulphates mentioned are not completely decomposed by muriate of ammonia, but only in part. Water, containing common salt or muriate of ammonia, dissolves a much larger quantity of sulphate of lime than pure water; but this salt is not decomposed, for by evaporation and heat, muriate of ammonia sublimed, leaving sulphate of lime unmixed with muriate.

When a very dilute solution of muriate of ammonia is left for a few minutes in contact with sulphate of lead, it is found to contain

a notable quantity of the metallic oxide. If a solution of muriate of ammonia is boiled with sulphate of lead, and the liquor be filtered while boiling, crystals of chloride of lead are formed, and the solution contains sulphate of ammonia: when the sulphate is repeatedly boiled in fresh portions of solution of muriate of ammonia, the sulphate of lead is eventually perfectly decomposed. Sulphate of lead is slightly soluble in water, for sulphuretted hydrogen and nitrate of barytes both occasion precipitation in it.—*Journal de Pharmacie,* September 1834.

PEROXIDE OF IRON AS AN ANTIDOTE TO ARSENIOUS ACID.

The following letter, addressed by Dr. Bunson to M. Poggendorff, is translated from the *Journal de Pharmacie* for October last.

Gottingen, May 1, 1834.

It is long since I observed, that a solution of arsenious acid is so completely precipitated by pure hydrate of iron recently precipitated, and suspended in water, that a current of sulphuretted hydrogen gas passed into the liquor after filtration, and the addition of a small quantity of muriatic acid, does not indicate the presence of the smallest portion of arsenious acid.

I have also found, that if a few drops of ammonia be added to this substance, and it be digested in a gentle heat, with arsenious acid reduced to fine powder, a subperarsenite of iron, which is perfectly insoluble, is quickly formed. A series of experiments, founded upon this observation, has firmly persuaded me that this substance combines the most favourable properties for serving as an antidote to arsenious acid, both solid and in solution. Dr. Berthold consented, at my request, to assist me in examining this subject in all its bearings, and to submit it to the most rigorous experiments. The results of this examination have much exceeded our expectation, and have confirmed us in the persuasion that perhydrate of iron is a better antidote for arsenious acid, both solid and in solution, than albumen is for corrosive sublimate.

Two young dogs, scarcely 12 inches high, had four to eight grains of arsenious acid given to them in fine powder, and the œsophagus was tied to prevent vomiting; they lived more than a week without exhibiting the slightest symptoms of poisoning by arsenic, either during life or on examination after death. The excrements voided were in very small quantity, for the animals were deprived of food and drink, and they contained almost the whole of the poisonous substance in the state of subperarsenite of iron.

We satisfied ourselves, by experiments upon animals, that a quantity of perhydrate of iron, equal to four or six drams of the peroxide of this metal, with sixteen drops of ammonia, is sufficient to transform in the stomach eight or ten grains of well-pulverized arsenious acid into insoluble arsenite. It is besides easy to see, that in cases of poisoning by arsenic, this substance, with or without ammonia, may be exhibited in much larger quantity, either by the mouth or as an enema; for the perhydrate of iron being a body totally inso-

luble in it, exerts no action on the animal œconomy.—*Journal de Pharmacie,* October 1834.

IMPROVED COMPASS-NEEDLES.

We are informed by a correspondent that Dr. M. Smith of Washington, United States, has effected a great improvement in the manufacture of magnetic needles for the compass. He has succeeded, it is stated to us, in producing a needle, which in the same place uniformly settles itself upon the same magnetic meridian; and all the needles which he prepares take the same line of direction. They appear to have more directive force, are less susceptible of local disturbance, and are more permanent in their properties than the common needles of ships' compasses. Seamen who have used them say that they are more steady in squally weather than those which they have been accustomed to employ.

Dr. Smith's needles, we are further informed, have been examined by the officers of the naval department of the United States, who, after verifying their indications and trying them at sea, have concurred in a favourable report of their qualities.

Dr. Smith will be happy to submit his needles to the inspection or examination of all persons who may be interested in the subject, upon their addressing a note to him, at the Museum of National Manufactures, Leicester-square.

ANALYSES OF OSMIRIDIUM AND ALLANITE.

The six-sided grains of osmiridium from Nischne-Tagilsk and Ekaterinenburg, described by Professor Gustav Rose, consist, according to Berzelius (*König. Vetensk. Acad. Handling.* 1833), of 25 iridium and 75 osmium. Their composition is consequently expressed by the symbol $I + 3\,Os$.

A specimen of allanite from Iglorsoit in Greenland, the specific gravity of which was 3·4492, has lately been analysed by Stromeyer: 100 parts gave

Silex	33·021
Alumina	15·226
Protoxide of cerium	21·600
Protoxide of iron	15·101
Protoxide of manganese	0·404
Lime	11·080
Water	3·000
	99·432

It gelatinizes readily in nitric and muriatic acid.

SCIENTIFIC BOOK.

Preparing for Publication.

By Prof. Phillips.

The Second Volume of Illustrations of the Geology of Yorkshire, with numerous Maps, Sections, and Plates of Organic Remains.

Also a new edition of the First Volume of that work.

OBSERVATIONS ON MR. STURGEON'S LETTER CONTAINED IN THE LOND. AND EDINB. PHIL. MAG. FOR NOVEMBER 1834. BY MR. FRANCIS WATKINS.

To Richard Phillips, Esq., F.R.S., &c.

MY DEAR SIR,

On looking over your valuable Journal for the last year, I was somewhat surprised to find in the November Number a letter from Mr. Sturgeon detailing the results of some experiments which he made in magneto-electricity the 28th of August 1834, with the large steel magnet belonging to the proprietors of the Gallery of Practical Science, Adelaide Street, Strand.

I take the liberty of calling your attention to the fact, that many months previously to the date of Mr. Sturgeon's experiments, (namely, on the evening of the 14th of November 1833,) I had the pleasure conjointly with Mr. Saxton (the projector and maker of the large and splendid magnet exhibited in Adelaide Street,) of illustrating in the presence of yourself, Messrs. Faraday, Lardner, Turner, Daniell, Cooper, Moseley, Pepys, and a host of other scientific gentlemen assembled at the Gallery, the mechanical, physical, and chemical effects of electricity developed by steel magnets.

You will, no doubt, recollect that on the evening in question I superintended a large magnetic machine which was very kindly lent at my solicitation by the Count de Predevalle, and constructed for that nobleman by the ingenious artist M. Pixii of Paris, while on the same evening Mr. Saxton displayed the splendid powers of the instrument contrived and made by himself.

There is nothing in these observations intended to underrate the merits of Mr. Sturgeon; indeed, I feel assured, had that gentleman been aware of what had been already done, he would not have forwarded his letter for insertion in your Magazine. Mr. Sturgeon I well know to be an ardent and zealous labourer in the field of physical science, and I hope you will allow me here to record, that I have received many friendly and valuable hints from that gentleman. Yet in justice to Mr. Saxton and myself, I could not let the opportunity pass of bringing to your recollection what had been achieved and experimentally illustrated months before the date of Mr. Sturgeon's experiments.

Should you consider it worth while to insert these remarks in your Miscellany, your readers will be apprised that what Mr. Sturgeon brings forward as new in magneto-electricity in August 1834, had been noticed by Mr. Saxton, myself, and others, many months previously. And it may here be observed, that notices of *polar* decomposition by magneto-electric agency were published in some French journals about the latter end of the year 1832.

I remain, my dear Sir, yours faithfully,

5, Charing Cross, Jan. 22, 1835. FRANCIS WATKINS.

Meteorological Observations made by Mr. THOMPSON at the Garden of the Horticultural Society at Chiswick, near London, and by Mr. VEALL, at Boston.

Days of Month. 1835.	Barometer. London. Max.	Barometer. London. Min.	Barometer. Boston. $8\frac{1}{2}$ A.M.	Thermometer. London. Max.	Thermometer. London. Min.	Thermometer. Bost. $8\frac{1}{2}$ A.M.	Wind. Lond.	Wind. Bost.	Rain. Lond.	Rain. Bost.
Jan. 1	30·631	30·145	29·56	46	34	44	N.	N.	...	...
2	30·856	30·814	30·35	40	29	37	SE.	calm	...	...
3	30·818	30·730	30·38	40	24	29	E.	calm	...	...
4	30·667	30·606	30·23	36	25	27	NE.	calm	...	...
5	30·606	30·601	30·20	43	22	35	E.	calm	...	...
☽ 6	30·555	30·444	30·22	31	18	37	SW.	calm	...	...
7	30·329	30·240	30·	28	20	26	SE.	calm	...	...
8	30·199	30·104	28·87	35	28	25·5	NE.	calm	...	...
9	29·936	29·688	29·49	48	33	36	SW.	calm	0·02	...
10	29·877	29·817	29·40	49	41	36	W.	calm	...	0·26
11	29·903	29·802	29·40	51	46	36·5	W.	calm	...	·44
12	29·946	29·900	29·60	52	38	38	SW.	E.	...	·32
13	29·731	29·570	29·38	50	39	42	S.	calm	...	·03
○ 14	29·541	29·475	29·03	50	44	44	S.	calm	·01	...
15	29·715	29·614	29·17	50	44	42	W.	calm	·08	...
16	29·496	29·081	28·55	47	31	48	W.	W.	·17	·18
17	29·889	29·623	29·13	42	22	33	W.	W.	...	·16
18	29·843	29·378	29·50	44	33	25	SE.	calm	·08	...
19	29·418	29·139	29·75	35	20	34	NW.	calm	·36	·16
20	30·303	29·850	29·57	38	20	30	NW.	NW.	...	·17
☾ 21	30·389	30·124	29·97	40	27	21	W.	calm	...	...
22	30·366	30·200	29·83	40	30	32	N.	calm	...	...
23	30·394	30·269	29·95	44	39	38	SW.	calm	...	...
24	30·283	30·158	29·64	51	35	44	SW.	calm	...	...
25	30·459	30·241	29·72	52	39	46	S.	calm	...	...
26	30·459	30·359	29·75	52	38	49	SW.	W.	...	...
27	30·456	30·412	29·85	47	36	39	SW.	calm	...	...
● 28	30·398	30·290	29·89	45	38	37	SW.	W.	...	...
29	30·220	30·149	29·68	53	39	42	SW.	calm	...	...
30	30·109	30·049	29·65	31	33	43	SE.	calm	...	...
31	30·192	30·030	29·60	48	37	37·5	SW.	W.	...	...
	30·856	29·081	29·65	53	18	36·5			0·72	1·72

Remarks.

London.—Jan. 1. Cloudy and fine. 2, 3. Hazy. 4. Clear and frosty. 5. Cloudy: clear and frosty at night. 6, 7. Dense fog: frosty. 8. Hazy. 9. Overcast: stormy and wet. 10. Clear and fine. 11. Cloudy: slight rain. 12. Overcast: fine. 13. Very fine. 14. Cloudy: rain. 15. Very fine. 16. Stormy, with rain. 17. Clear and frosty. 18. Frosty and foggy. 19. Slight snow. 20. Fine: sharp frost at night. 21. Frosty. 22. Fine. 23. Hazy. 24. Fine. 25. Hazy. 26—31. Overcast and fine.—The barometer on the 2nd, was remarkably high. The quantity of rain was extremely little for the period of the season.

Boston.—January 1. Stormy. 2. Cloudy. 3, 4. Fine. 5. Cloudy. 6. Fine. 7, 8. Cloudy. 9. Cloudy: rain P.M. 10. Fine: rain P.M. 11. Rain. 12. Cloudy: rain A.M. 13, 14. Cloudy. 15. Fine. 16. Rain and stormy. 17, 18. Fine. 19. Rain: snow and rain P.M. 20. Snow and stormy. 21, 22. Fine. 23—25. Cloudy. 26, 27. Fine. 28. Cloudy. 29. Fine. 30. Cloudy. 31. Cloudy.

THE

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PHILOSOPHICAL MAGAZINE

AND

JOURNAL OF SCIENCE.

[THIRD SERIES.]

APRIL 1835.

XL. *Notice of a Memoir on the Natural Laws which appear to regulate the Distribution of the Powers of producing Heat and Light among the different Groups of the Animal Kingdom. By* E. W. Brayley Jun., F.L.S., F.G.S., Librarian to the London Institution.

THE following paper was read before the Section of Natural History of the British Association for the Advancement of Science, at the meeting at Cambridge, on the 26th of June 1833. (Lond. and Edinb. Phil. Mag., vol. iii. p. 155.) It was then transferred to the officers of the Section, but by some accident was not received by the Secretaries of the Association, which precluded its appearance in the "Report of the Third Meeting;" since, although every facility for its publication was afforded by the Secretaries, the author was prevented by official engagements from preparing a fresh transcript in time for its appearance in that Report, in which, therefore, its communication only could be noticed in the "Proceedings of the Meeting." (p. xxxiv.) It is now printed exactly as it was read before the Section, a few verbal alterations excepted; the author intending, in a future communication, to announce some modifications and extensions of his views on the subject, which subsequent inquiries, and certain recent discoveries as well in zoology as in physics, have induced him to propose.

It may be well to add, in explanation of the particular form of the communication, that it was drawn up in express compliance with the desire intimated in the preface to the "Report of the First and Second Meetings" of the Association,

that the miscellaneous papers should be delivered in and read to the meetings in an abbreviated form, ready for immediate publication.

Should the original transcript read at Cambridge happen to have remained in the hands of any member of the Section of Natural History of 1833, the author will feel obliged by its being returned to him.

London Institution, Feb. 7, 1835.

On comparing and classifying the facts constituting our present knowledge of those functions of the animal œconomy which are connected, respectively, with the production of heat and light, as existing, in their various gradations, throughout the animal kingdom, certain laws have appeared to the author to regulate the distribution of those functions. The complete verification of these laws will require the ascertainment of a great number of new facts; comprising observations on the *natural temperature* of many species among vertebrated animals, and of the amount or intensity of the *light* emitted by a large majority of the marine invertebrated animals and a few insects; as well as some very delicate researches on the temperature of certain species of each division not hitherto regarded as having the power of maintaining a temperature higher than that of the medium in which they live. The chief object of the author, therefore, in the memoir of which the present notice is intended as a brief *Prodromus*, is to announce, as approximations, the natural laws in question, and to draw to these subjects the attention of men of science; especially of physiologists and of scientific travellers, on the latter of whom the demonstration of them will in great measure rest; the author acknowledging his inability at present fully to verify the laws, the future demonstration of which he nevertheless ventures, with some confidence, to predict.

In referring to the production of heat by animals, the author means what is commonly understood by the term *animal* or *vital heat*,—the result of the power of maintaining, in the living body and as a consequence of life, a temperature independent of that possessed by the medium in which the animal is immersed, or by the substances with which it may be in contact.

In referring to the production of light by animals, the author means what has been termed by Professor Macartney *animal light**,—the result of the power of becoming luminous, as a consequence of life, and as manifested by the animals

* Philosophical Transactions for 1810, p. 289.

which are said to be *luminous* or *phosphorescent*, such as the glow-worm and the fire-fly among insects, and many species of minute *Medusæ* and *Crustacea* among the inhabitants of the ocean.

The author deduces from all the facts hitherto promulged on these subjects, the following principal law: viz. *That in the animal kingdom the powers of producing* (*or evolving*) *heat and light*, *respectively*, *are reciprocally in the inverse ratio of each other*.

Of this law, with reference to its consequences in particular cases, the following statement may be regarded as an expansion; that classification of the animal kingdom being adopted for the purpose, which has been shown, by Mr. William S. Macleay, by a course of strict induction detailed by him in his *Horæ Entomologicæ*, to express the natural affinities of the beings composing it.

If we represent by a circle, as Mr. Macleay has done*, the series of affinities returning into themselves, which is presented by the beings of the animal kingdom, when we consider the totality of the characters of every species with reference to the totality of those of every other species, and to the aggregate character of each of the more or less comprehensive groups into which they are connected by their mutual affinities, we shall observe, on comparing this mere expression of known affinities with the facts relating to the production of heat and light by animals, the following phænomena.

In the Mammalia and Birds, forming a certain arc of the circle, animal heat is at its maximum; while *animal light* does not sensibly exist, and if it exist at all is at its minimum.

In certain Crustacea, Radiata, Acrita, and Tunicata †, forming an opposite arc of the circle, animal light is at its maximum, while animal heat does not sensibly exist, and if it exist at all is at its minimum.

* *Horæ Entomologicæ*, p. 318. In order that the members of the Section of the British Association before whom this paper was read might be enabled readily to trace the distribution of animal heat and light here announced, a large diagram was exhibited to them, which was an exact transcript of that given by Mr. Macleay, *loc. cit.*

† The phænomena of natural distribution discovered by Mr. Macleay, and the arrangement of the animal kingdom which is the expression of those phænomena, being even yet far less known to the scientific world than their importance demands, his nomenclature, though differing very little from that of contemporary naturalists, (having been, in fact, for the most part selected from their works,) may not be immediately understood, especially as it contains some peculiar applications; a few synonyms of the groups mentioned in this paper are therefore subjoined.

The groups denominated Vertebrata, Mammalia, Birds, and Fishes, require

Among Fishes, in which we approach the first sensible termination of the function of animal heat, on advancing towards the passage from the vertebrated to the invertebrated animals by means of the intermediate group of Annelida, we first observe among the Vertebrata a decided tendency to the production or development of animal light; without, however, that power being actually attained until we come to the Annelida themselves, constituting the next group:—the proofs of these facts requiring much explanation and discussion, are necessarily reserved for the Memoir itself. Corresponding phænomena are observable among the Coleopterous insects forming part of the Annulosa.

These facts indicate that the extreme terms of the *animal-heat series*, including (so far as our present knowledge extends,) Birds, Mammalia, and certain Fishes,—and those of the *animal-light series*, including genera or species belonging to every great group of Invertebrata, and to two, at least, of the intermediate or osculant groups (viz. Annulosa, Radiata, Acrita, and Mollusca;—Annelida and Tunicata)—the terms of apparent evanescence of each power—are connected together by a gradual transition and exchange of functions. Thus the general result to which these facts lead is, that, regarding the entire animal kingdom, we may observe,—commencing with the maximum point of animal heat,—a gradual diminution of the power of producing it, while the power of producing animal light, or at least a tendency towards it, as gradually takes its place, rises to its own maximum, and in its turn gradually diminishes and is reciprocally replaced by the power of pro-

no explanation; those designated Annelida, Annulosa, Arachnida, Crustacea, Cirripeda, and Cephalopoda, are also substantially the same with those of other naturalists.

The Reptilia of Macleay include those of Brongniart and Cuvier, with the exception of the *Batraciens*, which constitute Macleay's Amphibia. The Ametabola include those of Leach, and, generally, all those Annulosa which, "constructed on the same plan with the larvæ of true insects," "are rendered incapable by Nature of completing their metamorphosis, and are able to perform the offices of adult life in all the various stages of an incomplete change of form. (*Hor. Entomol.*, p. 287.) The Mandibulata and Haustellata are those of Clairville, being the *Insectes Broyeurs* and *Insectes Suceurs*, respectively, of several of the French naturalists. The Acrita comprise, under the name of Intestina, such of the *Intestinaux* of Cuvier as form the greatest part of his second and third divisions of *Intestinaux parenchymateux*, and of the *Vers mollasses* of Lamarck; the *Polypi natantes*; the *Polypi vaginati* of Lamarck; the *Polypi rudes*; and the *Agastraires* of Blainville. The Tunicata are the *Tuniciers* of Lamarck, the *Acéphales sans Coquilles* of Cuvier. The Mollusca agree with those of Cuvier, excluding the order last named, together with the *Cephalopodes* and the *Cirrhopodes*, which, like the Tunicata, are formed into distinct osculant groups.

ducing heat, or a tendency to it, which at length attains its maximum, whence we began the survey.

There appears to be no instance in which all the species, either of a great or of a subordinate group, are luminous, contrary to what obtains with respect to animal heat; nor have all the species this character in either of the two osculant groups certain members of which are luminous. On reviewing the entire animal kingdom with respect to the comparative number of species at present known or regarded to produce heat and light respectively, the facts appear to be as follows. In the vertebrated animals *animal heat* is found in all the species composing the subordinate groups of Mammalia and Birds, and in a low degree in a few species of Fish. Its existence in Reptiles and Amphibia has not yet been shown. In the osculant Annelida a few species are *luminous*. In the Annulose circle, a few species among the Ametabola, Mandibulata, and Haustellata are luminous; and a few others, of the second of these groups, have, it is probable, but not yet certain, a low degree of animal heat; while of the Crustacea very many species are luminous. Among the Radiata many species of Medusida have this property; among the Acrita certain species of *Polypi Natantes*; the osculant Tunicata present many of the most extraordinary instances of luminous power; and a few species also in the succeeding great group or subkingdom of Mollusca, by which, through the Cephalopoda, we arrive again at the Vertebrata, have a degree of the same power.

Thus *animal heat* exists principally among the typical Vertebrata,—Mammalia and Birds; and *animal light* principally among those animals of the other subkingdoms of zoology the structure of which is the furthest removed from the vertebrated type: and there are various indications, between the Crustacea and the Mammalia, on reviewing all the phænomena presented by the intervening subordinate groups of Fishes, Annelida, Ametabola, Mandibulata, Haustellata, and Arachnida, of the reciprocal substitution of a degree of the one power for the other, as we pursue the facts showing approximately the diminution of animal light upwards in the scale of organization, through the above series, from the Crustacea to the Mammalia, and the diminution of animal heat downwards in the scale, from the Mammalia to the Crustacea. The facts affording these indications will be detailed and discussed in the Memoir.

Although Mr. Macleay's classification has been adopted in this notice as being at once the most convenient for the present purpose, and the first approximation yet effected to the

natural system of the animal creation, in all its generality, the author wishes it to be understood that the views he has explained above are in no degree necessarily dependent on Mr. Macleay's views of natural distribution, which, on their part, are equally independent of the author's views of the distribution of the powers of producing heat and light. At the same time the demonstrable truth of Mr. Macleay's inductions, furnishes, when those inductions are pursued to all their consequences, a strong *à priori* case in favour of the author's; and conversely, if the author's shall be found correct, a strong confirmation of Mr. Macleay's will be afforded; because,—while that zoologist infers the natural distribution of animals from the totality of their structure and its variations,—the author virtually infers their natural distribution from one or two particular functions or points of structure; and the arrangements inferible respectively from these methods, if they are both true, *should exactly coincide*; so far, at least, as the arrangement inferred by the latter method professes to be complete. An examination of this subject will form part of a subsequent communication.

Finally, the author having been obliged to reserve for the Memoir itself, on account of the detailed discussion which they require, the proofs of the exchange of a certain degree of animal heat for an equivalent degree of animal light, and *vice versâ*, as we proceed in the zoological series in either direction from the maximum of either power, towards its minimum and the maximum of the other, on which the demonstration of the law here announced depends, is desirous that naturalists and natural philosophers should receive the announcement,—not as a law alleged to be ascertained—but merely as a prediction hereafter to be verified. To the disproof or verification of this, nothing will tend so greatly as a series of exact researches on the vital heat of animals of various classes, especially of those which appear to lead from one group to the other; as the Penguins among Birds, which, as Mr. Macleay has shown *, evidently approximate to the Reptiles; the Cetacea among Mammalia; and the viviparous Sharks, which, through the former group, connect the latter with Fishes. Minute researches are also wanting on the temperature of the Reptilia, and more particularly on that of the Chelonian reptiles. But for these purposes, and especially for that of ascertaining the difference of temperature between animals of the same or of contiguous groups, and for determining whether animals not hitherto regarded as enjoying vital

* *Hor. Entomol.*, p. 264.

heat, have not, in fact, a certain small amount of it, very delicate thermometers will be required. These instruments must be susceptible of indicating variations of temperature equivalent only to small fractions of a degree on any of the scales at present in use, as the differences of temperature of nearly allied species, in the one line of research, and those between the animal and the ambient medium, in the other, must unquestionably be very minute.

A popular exposition of this subject, including the enunciation of the approximate law above explained, was delivered, in the form of a Lecture, in the Theatre of the London Institution, to the company assembled at a *Conversazione* on the 27th of February last (1833), on which occasion the foregoing views were for the first time explicitly announced.

London Institution, June 19, 1833.

XLI. *On the Achromatism of the Eye: in reply to some Remarks in the Lond. and Edinb. Phil. Mag. and Journal of Science, No.* 33. *By the Rev.* B. Powell, *M.A., F.R.S., Savilian Professor of Geometry, Oxford.**

OBSERVING in the last Number of this Journal (p. 161) that Sir David Brewster has honoured my paper on the achromatism of the eye with a notice, I think it necessary, in order to prevent misconception, to offer the following brief statement in reply.

1st. I believe I have stated in my paper, that I readily admit that *many individual eyes may not be achromatic.* If the dispersive powers of the media vary ever so little, the achromatic adjustment may be destroyed. I am therefore far from wishing to controvert any particular observations which may show that individual eyes have not the requisite adjustment.

2ndly. The main object of my paper was to show, in contradiction to the assertions of many theoretical writers, *that in a combination similar to the eye, achromatism is perfectly possible in principle.* Their position is that the result is *impossible* upon *theoretical* and *mathematical* grounds. I have shown in a way which can only be refuted by disproving the whole established theory of foci and refractive indices, that, as far as theory is concerned, achromatism is perfectly obtained, in a combination of a lens and one medium, if only the indices and radii fulfill the conditions of a certain formula. I have also shown by observation, that in the particular in-

* Communicated by the Author.

stance of an ox's eye the indices are as nearly as possible in the required ratio.

3rdly. It follows as a necessary and mathematical consequence that an eye may be perfectly achromatic for direct centrical pencils, though not for excentrical and oblique pencils, which appears also to accord with observation.

These positions, I believe, will be found to stand quite independently of Sir D. Brewster's remarks, which may yet be perfectly correct in reference to the particular cases examined, and I should be among the first to acknowledge their value as bearing those marks of excellence which characterize all the observations of their author.

Oxford, March 3, 1835.

XLII. *Trigonometrical Height of Ingleborough above the Level of the Sea.* Part I. *By* John Nixon, *Esq.**

[With a Plate.]

MY *standard* altitude, that of Ingleborough, having been originally determined from insufficient data†, the details of a more satisfactory measurement are now presented.

All the requisite observations might have been made at any of the numerous places on the margin of the sea in the bay of Morecambe, which command a view of Ingleborough and several other stations of the Ordnance Survey; but as differences of level may be measured with peculiar advantages from intermediate positions, four eminences situated between Ingleborough and the bay were fixed upon as stations whence the elevation of the hill and the depression of Hest breakwater pole could be observed.

A brief description of the stations and their signals may not be deemed superfluous. About two miles north-east of Burton-in-Kendal a saddle-shaped ridge, chiefly of limestone, extends upwards of two miles from north-west to south-east. The precipitous northern end, noted for its resemblance to the Rock of Gibraltar, is called *Farleton Knot*. Near the south-west side of the boundary wall that runs along the watershed of the ridge, a lofty pile of huge fragments of rock, constructed, from the difficulties of the situation, of an irregular figure, was erected upon a highly inclined bed of limestone, close to its basset edge at the loftiest point of the Knot. The southern, more gradual termination of the ridge, is known by the names of *Hutton-Roof Moor* (or *Crags*) north-east of the division wall, and of Dalton Fell south-west of it.

* Communicated by the Author.

† See Philosophical Magazine for 1823, vol. lxi. p. 262.

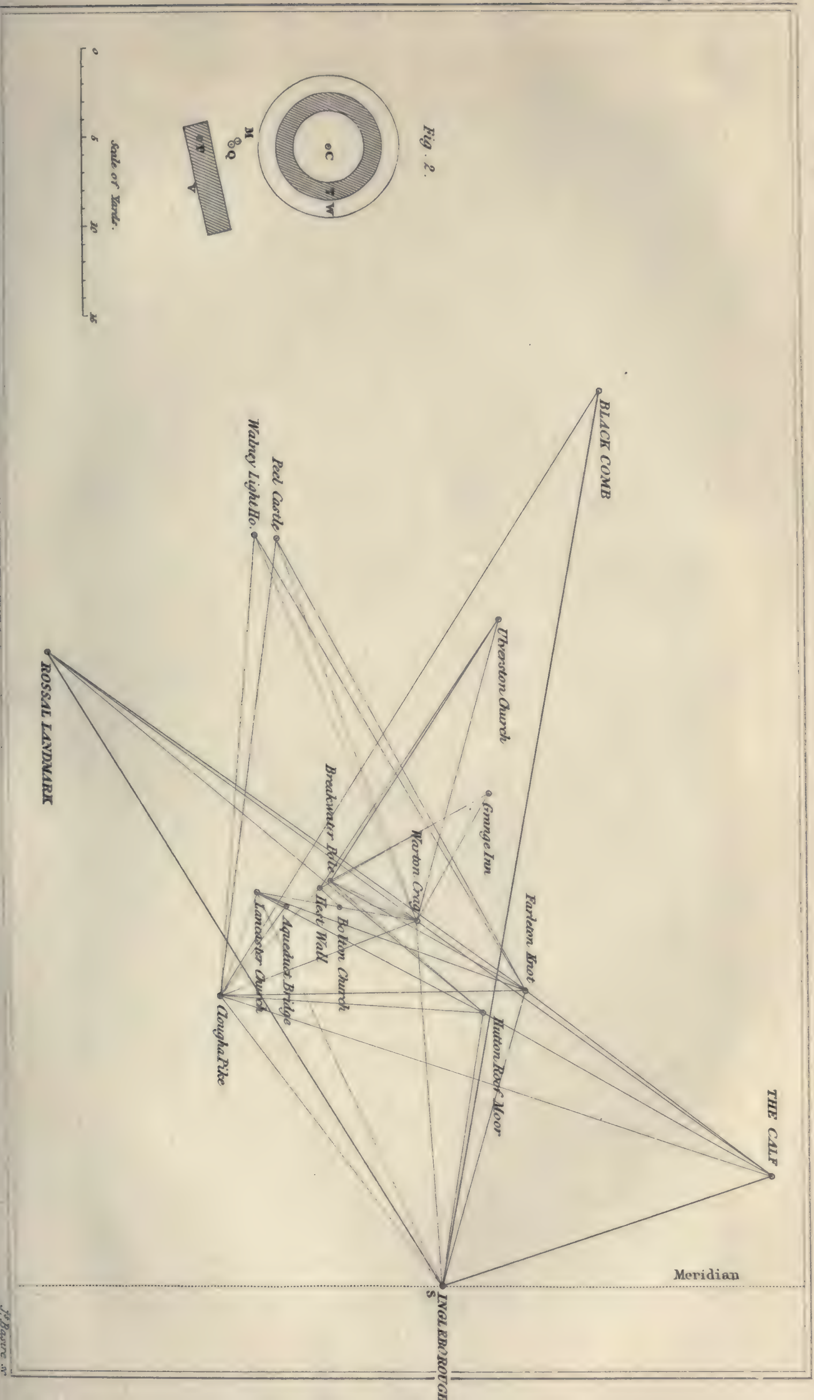


Fig. 2.
C
T
W
M
Q
V
Scale of Yards.
0
5
10
15
BLACK COMB
Peel Castle
Walney Light Ho.
Ulverston Church
ROSSAL LANDMARK
Grange Inn
Breakwater Pole
Warton Crag
West Wall
Bolton Church
Farleton Knot
Lancaster Church
Aqueduct Bridge
Clougha Pike
Hutton Roof Moor
THE CALF
Meridian
S
INGLEBOROUGH

J. Basire sc.

The large conical signal, regularly built of limestone rock, was based on a piece of verdant level ground 365 feet south-west, and 3 feet below the level, of the extreme summit of the moor (and of the entire ridge). On the crown of *Warton Crag*, a limestone knoll* situated between Warton (seven miles north of Lancaster,) and the eastern shore of the bay of Morecambe, stands a large boulder rock, on which was raised a tall but slender pile of stones. *Clougha Pikes*, two noted landmarks five miles E.S.E. of Lancaster, stand on the ruins of a building which marked the boundary between Wyersdale and Lunesdale at the abrupt termination of a grit ridge extending in a westerly direction from Bolland Forest. The eastern pike was considerably reduced in height to avoid mistaking it for the other, which was formed conical, but with an axis unavoidably so much inclined as to render it very difficult of accurate bisection†. Principally to obtain the height of Lancaster church tower above the canal, a few observations were made at the bridge one mile from Lancaster, on the road to Kirkby Lonsdale, and at a station 64½ feet to the south-east, on the towing-path of the canal near the aqueduct across the Lune.

A few observations on the identity of site of my signals with those of Colonel Mudge at such of his stations, &c., as were adopted as a basis for the triangulation may not be improperly introduced here. At the *Calf*, five miles north of Sedbergh, the highest ground or nearly so‡ of the Howgill (clayslate) Fells, the turf signal stands precisely where were found wooden stakes, numerous loose stones, &c., the usual vestiges of the Colonel's stations. From the regular figure and great size of the pike on *Black Comb*, it forms, no doubt, although apparently not placed on the highest part of the fell, one of the numerous signals erected a few years ago at Colonel Mudge's stations in the Lake district by the party engaged in extending his survey into Scotland and Ireland. As the diminutive pike seen from Hest-bank and other low situations at some distance to the left of the other, is invisible from elevated ground, it is most probably placed as a guide on the side of the crest of the hill. *Rossal Landmark*, a lofty

* On Warton Sands dull-red grit, horizontally bedded, rises a few feet above the level of high-water mark, and abuts (?) against the western flanks of the Crag.

† Cylindrical signals are much superior in this respect to those of a conical figure.

‡ When the telescopic level, resting on a stone about a foot high, pointed at a knoll nearly a mile to the southward, the bubble stood between its marks.

conical tower 14 miles south-west of Lancaster, erected on a short but steep acclivity* near the margin of the sea, although built of wood and standing in a very exposed situation, may nevertheless be the identical mark of the Ordnance Survey, and not its substitute, placed perhaps not exactly on the same base. The sands around being extremely loose, and the difficulty and hazard of transporting the instruments across the Wyre represented as considerable, the idea of making observations at Rossal Landmark was abandoned. Mudge's station on Ingleborough is described as bearing 67 yards (= 201 feet) east of the old (shepherd's) hut, and marked by a great number of very large stones placed round it. According to one of the secondary triangles, an "old building" on the hill would bear 80° 18′ S.W., 200 feet. In 1822, a lofty pike (P), (See Plate, fig. 2.) standing at the western end of an old wall (V) (18 feet long and 4 feet thick), used for hoisting the beacon tar-barrel, bore 80° 2′ S.W., 200 feet of a heap of stones, considered to be those marking the station†; the theodolite standing, to the best of my recollection, exactly over their centre. As the pike and the "old building" were equidistant from the station and within a foot of the same direction, they were probably identical. In 1829, a pike (Q) on the old wall, undoubtedly the same as the one observed in 1822, bore from my signal (S) 88° 37′ S.W., 202 feet, or about 5 feet north of the previous direction. It may therefore be suspected that the present signal (S) (which is 8 feet high and 4 feet in diameter) was built, contrary to my instructions, not on the site of the original one (at the heap of stones), but about 5 feet to the N. by E. The tower (T), 18 feet in diameter, bears 84° 40′ S.W. of the signal (S), their centres being 197 feet distant. The foundations of the terrace (W), 24 feet in diameter, cover those of the old hut, of which no plan has been preserved. It is not specified from what part of the hut the 201 feet were measured, but the distance from the heap of stones to its centre, supposing it to coincide with that of the tower, will be only 195½ feet. Mr. R. Clapham of Feizor (to whom I am indebted for the plan of the

* The height of the tower top was not observed from any of the stations, but in the calculation of the zenith distances it was estimated at 100 feet above low-water mark.

† A gentleman resident in Ingleton who had ascended the hill every year from the date of the Colonel's visit, assured me that the stones had never been disturbed in situation. At some of the Ordnance stations I have found a cylindrical block of oak, pierced in the centre, sunk a few feet below the surface of the ground, but none could be discovered either at Ingleborough or the Calf.

tower, &c.) is of opinion that the walls pointed N.W. and N.E., which would throw its centre further from the station.

The signals on Farleton Knot, Hutton Roof Moor, and Warton Crag were *whitewashed** from the base nearly to the top to render them distinguishable at the more elevated stations from the chaos of rocks, &c. of the same hue immediately around them. Under a bright sky these signals are so intensely brilliant that they have been seen from distant stations sufficiently distinct for bisection when the hills on which they stood were enveloped in light mist or haze. Marks of this description have, however, their disadvantages, not only fading gradually out of view as the sun advances towards the same quarter of the horizon, which requires in strictness a correction for unequal illumination, but causing on a partially cloudy day numerous tedious interruptions, to the probable injury of the observations. At the Calf, on a bright clear day, none of the signals, owing to their situation to the southward, could be satisfactorily identified, with the exception of that on Farleton Knot, recognised from its proximity to the division wall and the precipitous edge of the scars †.

Whenever the signal on Ingleborough appeared from any other station to have been thrown down, (as was frequently the case until a person was appointed to watch it,) one, and sometimes both sides of the adjacent tower were observed in lieu of it, and the corresponding correction calculated from data of undoubted accuracy. As the flagstaff on Lancaster church tower, which is only nine inches in diameter, could never be seen at Ingleborough sufficiently distinct for bisection, the north-west or south-east, and in some instances both angles of the tower were observed, and the reductions to the flagstaff computed from a plan of the tower by J. Binns, Esq. ‡.

Of the Distances.

In 1829 and 1830 the requisite angles were measured by my six-inch theodolite on different parts of its divided circle; but in consequence of the marked differences in the distances derived from the three base lines made use of, the survey was resumed in 1832, with an additional or verification base line (that of the Calf to Ingleborough), and the angles measured,

* When the solution of lime in water is applied hot, it will adhere to the rock and retain its colour several years.

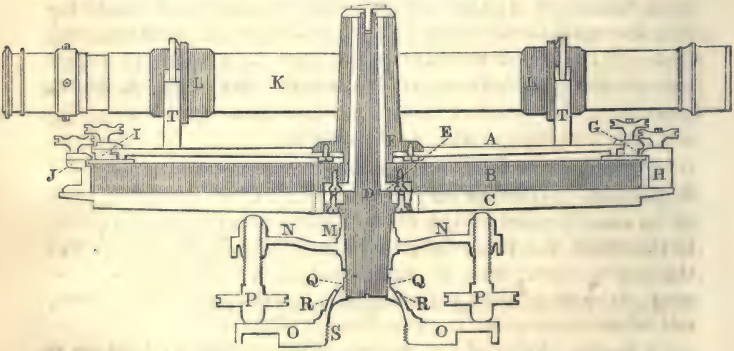
† A white signal seen against a clear sky with a low sun in the same quarter, or on a gloomy day, appears of a dull lead colour, and if highly conical will have a figure nearly cylindrical.

‡ The sides of the tower are of different lengths, and the flagstaff is not placed at the intersection of the lines drawn (diagonally) from the angles.

for the greater certainty, oblique to the horizon, and on the repeating principle. As the new data, although partially explanatory of the previous discrepancies, proved unsatisfactory in some minor respects, the principal angles were remeasured the following year by my repeating circle, recently fitted up by Mr. Lealand with new axes, Ys, and telescope.

The theodolite is identical in construction with the one figured at page 8 of Mr. Simms's Treatise on Surveying-Instruments, and would measure horizontal angles by repetition, as described at pages 15—16 of the same work, were not the tangent screw of elevation so powerful as to disturb the feeble clamping-apparatus of the two circles. When the multiple of an *oblique* angle is required, adjust the upper circle and the line of collimation to be parallel to the horizon, and consequently to each other. The circle must then be got into the plane of the two signals by the two pair of screws of the parallel plates; and when this is effected the telescope will bisect in succession both signals as the upper plate moves about its axis, and the process of repetition may be conducted in every other respect precisely the same as for horizontal angles. The circle would generally keep in the plane required, but in some instances the deviations, which are most sensible in large angles, would gradually become so important as to require a renewal of the adjustments (which may be effected without interrupting the series of repetitions).

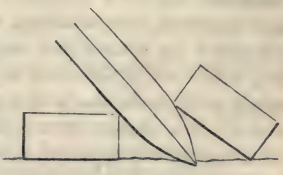
Mr. Nixon's Repeating Circle.



In giving a description and drawing of the repeating circle, the object is more to exhibit its defects and objectionable peculiarities than to hold it out as superior, or even equal, to those of the usual construction. In the figure which represents (on a scale of quarter size) a vertical section of the instru-

ment through its axis, C is a radiated wheel with a solid conical axis D*, on which revolves the hollow axis E of another radiated wheel B. A is a circular graduated *plate*, of which the hollow axis F is moveable about that of the wheel B. The divisions have a radius of $5\frac{1}{2}$ inches, and are read off to 10″ on two opposite verniers fixed to the wheel B. The *plate* supports a pair of Ys TT, (placed on one side of the axis,) in which rests an eighteen-inch telescope K, fitted up with cylindrical collars LL†. The line of collimation lies $1\frac{1}{2}$ inch above the *plate*, and about the same distance to the *left* of the centre of the divisions. The plate A and wheel B are both cut into teeth at the circumference, the former being turned by the pinion G (fixed to B), and the latter by the pinion H (fixed to C). The wheel B can be secured to that of C by the clamp J, and the plate A to the wheel B by the clamp I. The upper parallel plate N N, carrying two pair of screws P P, fits to the inferior part of the axis D by means of the hollow cone M. The lower plate O O is secured by its socket R R to the same axis by screwing up the ball Q Q. The screw S serves to fix the instrument to the head of a tripod staff similar to the one drawn at page 8 of Mr. Simms's Treatise‡.

The circle has only one telescope, and as the ground at the stations where it was used proved impenetrably hard, it was highly important that the staff should be set up immoveably firm. The (inflexible) legs being *well* extended, a flat stone or flag, at least a foot square, and nearly six inches thick, was laid under and in close contact with each leg. Another flag, equally thick and broad but much longer, was reared lengthwise against the outside of each leg, a little above its contact with the under stone. Both flags should be quite firm, and front the centre of the circle on which the legs stand. The figure in the margin is a vertical section of the two flags and leg through the points of contact. Perfectly successful as is the method, without regard to the force of the wind, on massive rock, it was generally found to fail when attempted on any less



solid basis. At Clougha, the instrument being well set up on

* The parts constructed of bell-metal are shaded in the figure.

† In the plate the telescope and Ys are given in elevation.

‡ The circle was made *to order* by the late Mr. Allan, and cost about 30*l*.

ground apparently quite firm, a certain angle was satisfactorily repeated to the fifteenth time, when it was discovered that my moving two or three feet to the right caused the telescope to swerve in azimuth. On repeating the measurement at the foundations of the old building, the previous one proved to be nearly 15″ in excess *.

The Ys being constructed of equal height, (as was proved by the *reversed* telescope pointing at the previous mark on turning the circle half round in azimuth,) the line of collimation was rendered parallel to the (divided) plate by adjusting it to bisect the same distant mark during a revolution of the telescope within its Ys. One of the cross wires being set parallel to the plate, (in which case both extremities bisect the same object as the plate revolves,) a minute dot, adhering to it a little to the left of the vertical one, was advantageously substituted for their point of intersection.

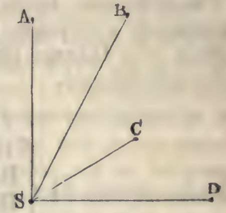
The graduated plate is got into the plane of the two objects by the screws of the parallel plates. Unfortunately the socket yielded to the *forcible* action of the screws, which increased at every adjustment the distance between the parallel plates and produced a simultaneous movement in azimuth. On finishing an adjustment, in order to avoid any subsequent deviation of the circle in plane or possibly in azimuth, the screws were left equally tight. The process of observation may be briefly described with reference to the figure. Having fixed the clamp I, turn the pinion H until the telescope bisects the signal x. Fix the clamp J, and having registered the reading, unscrew the clamp I. Move the pinion G to bring the telescope to bisect the signal y. Then fix the clamp I, and having obtained the reading, unscrew the clamp J, and turn the pinion H until the telescope points again at x. Lastly, fix J, and having unscrewed I, move the pinion G until the signal y becomes bisected the second time. Fix I, and register the reading, which will differ from the one first obtained by *double* the angle required. After this manner any other multiple of an angle may be measured. Bisections made with rack-work and pinion are, from the interfering action of the clamp, more difficult and tedious to effect than by a tangent screw, (of which *two* are used in repeating with a theodolite,) but unquestionably they are more permanent †. Several angles measured on the theodolite would exhibit at

* A circle with *two* telescopes would have been equally liable to the error.

† Mr. Lloyd's superb level (by Cary) would not retain the adjustments of its bubble when effected by an endless screw.

every successive repetition either a gradual increase or decrease*, whilst those obtained by the circle beyond the multiple requisite to clear the angle of the error of reading † rarely oscillated out of the limits of 2″ or 3″.

At the station S we may procure, by simple subtraction, an additional measure of the angles subtended by the signals A B, B C, and C D, by observing also those formed by A C, A D, and B D. At Ingleborough, out of 14 angles obtained by the circle (of which there were on an average 4 measures), the mean error was about 3″, and the maximum 8″; at Clougha, the mean error out of 13 angles (of which there averaged 3 measures) was 6″, and the greatest 12″. The mean difference between 39 (oblique) angles by the theodolite and the circle equalled 11″, the *signs* in all the cases being disregarded ‡.



Calculation of the Distances.

Corrections.—The verniers of the circle are fixed too near, and those of the theodolite too far from the centre of the graduations, the former requiring a mean correction of +2″, and the latter of −1″ per minute. The trifling excentricity of the telescope of the circle was disregarded. The correction for the partial illumination of the whitewashed signals was allowed for in the bisection. The reduction of the angles to the centre of the signal was carefully computed from exact data. Oblique angles were reduced to their horizontal value by both the *formulæ* of Dr. Maskelyne. The horizontal distances were verified by those calculated with the oblique angles and bases, the latter being first reduced to the same plane.

* *Strictly* speaking, the error of the first reading cannot be exterminated in the longest series of repetitions.

† The verniers being too far subdivided and the lens unfixed to the instrument, the error of reading might amount to 20″ or 30″.

‡ As a specimen of the capabilities of my repeating circle, I give the two measurements at Ingleborough obtained with the highest multiple.

Rossal Landmark and Hutton Roof Moor.		*Rossal Landmark and Farleton Knot.*	
40° 51′ 7″	by multiple of 5	47° 47′ 8″	by multiple of 5
5	10	9·5	12
8	17	7·5	16
8	22	7·5	20
9	26		

N.B. Angles by the circle are marked C, and those on the repeating principle by the theodolite T, the figures affixed denoting the multiple of repetition. Horizontal angles by the theodolite are marked *t*, with the number of observations affixed. The figure is omitted when the angle has been obtained merely by the addition or difference of other angles. The difference between 180° and the sum of the observed angles of a triangle is given within brackets. The rational mean of a distance derived from different bases is stated in the last column.

Horizontal Distances.

Ingleborough to	The Calf	77614·5 ft.	From the Ordnance Survey.
	Rossal Landmark	166545·	
	Black Comb	201970·	
	Lancaster church tower	97174·	
The Calf to	Ditto	131605·5	
	Rossal Landmark	199862·	

Triangles.

	°	′	″			
I.						
Ingleborough	75	54	47½	C 11	82054·2	82053·8 ft.
The Calf	54	5	5½	0*	98269·3	
Warton Crag	50	0	7	C 17, 16		
II.						
Ingleborough	27	55	20	C 10	82053·1	82053·8
Rossal Landmark	22	13	23½	0	101591·	
Warton Crag	129	51	16½	C 16		

Hence the distance from the Calf to Rossal Landmark will be 199860 or 2 feet in defect.

III.	[−3″]					
Ingleborough	56	3	13½	C 14	67990·5	67990
The Calf	54	53	41	T 14	69843·1	
Farleton Knot	69	3	5½	C 16		
IV.						
Ingleborough	47	47	6	C 20	67989·0	67990
Rossal Landmark	22	37	4½	0	130932·7	
Farleton Knot	109	35	49½	C 16		

Hence the distance from the Calf to Rossal Landmark will be 199863 or 1 foot in excess.

* The cipher denotes that the angle was not measured, but obtained by subtracting the sum of the two others from 180°.

V.				
Ingleborough	62° 59′ 31½″	C 7, 12	61512·3	61512·5ft.
The Calf............	47 48 25½	0	73970·8	
Hutton Roof Moor	69 12 3	C 16		
VI.				
Ingleborough	40 50 52½	C 26	61513	61512·5
Rossal Landmark	18 31 58½	0	126578	
Hutton Roof Moor	120 37 9	C 15		

Hence the distance from the Calf to Rossal mark will be 199863 or 1 foot in excess*.

VII.				
Ingleborough	109 16 4½	C 10	81530·7	81529·8
The Calf............	36 22 0	0	129798·3	
Clougha (West) Pike............	34 21 55½	C 14		
VIII.	[+9″]			
Ingleborough	33 21 5	C 8, 18	81530·7	81529·8
Warton Crag	72 42 45½	C 16	46944·0	
Clougha Pike	73 56 9½	C 12		
IX.	[+20″]			
Ingleborough	53 12 41	C 20	81531·0	81529·8
Farleton Knot......	73 38 34	C 14	68048·4	
Clougha Pike	53 8 45	C 16		
X.	[−3″]			
Ingleborough	46 16 40	C 5, 13	81525·8	81529·8†
Hutton Roof Moor	84 59 24½	C 13	59144·6	
Clougha Pike	48 43 55½	C 16		

* Mudge's data give 54° 0′ 36″ for the angle at the Calf between Ingleborough and Rossal Landmark; the same angle by the data of Triangles I. and II., III. and IV., V. and VI., will be in error +6″, −2″, and −8″ respectively. The corresponding errors in the angle at Rossal Landmark, between the Calf and Ingleborough, will be +2″, −2, and −1, Mudge's (calculated) angle being 22° 9′ 8″.

† As the observed angles of the following triangle were not measured by the circle, it was deemed proper to exclude it from the text.

XI.				
Ingleborough	47° 40′ 33″	T 10	81516·0	(81529·8)
Black Comb	22 16 54	0	158952·4[a]	
Clougha Pike......	110 2 33	T 12		

[a] With the included angle at Ingleborough 47° 40′ 33″, and the sides 81529·8 and 201970, we get 158947·2 feet for the distance from Clougha to Black Comb. (See also Triangle XXIX.)

	°	′	″			
XII.						
Ingleborough	12	12	23½	C	97203·0	97198·1 ft.
Clougha Pike	123	15	7½	C 13	24576·2	24570·8
Flagstaff on Lancaster Church Tower	44	32	29	0		
XIII.						
Ingleborough	21	8	47	C 12 / 6	97201·3	97198·1
Warton Crag	103	47	0	C 13	36105·3	36104·8
Lancaster Church	55	4	13	0		
XIV.						
Warton Crag	31	4	7	C 12	36104·4	36104·8
Clougha Pike	49	18	47	C 15	24571·6	24570·8
Lancaster Church	99	37	6	0		
XV.						
Ingleborough	41	0	26	C 13	97197·5	97198·1
Farleton Knot......	94	48	7	C 16	64001·2	64001·6
Lancaster Church	44	11	27	0		
XVI.						
Farleton Knot......	21	9	26½	C	64002·0	64001·6
Clougha Pike	70	6	13	C 16	24566·7	24570·8
Lancaster Church	88	44	20½	0		
XVII.						
Ingleborough	34	4	11	C 10	97192·0	97198·1
Hutton Roof Moor	109	14	3½	C 14	57666·0	57668·4
Lancaster Church	36	41	45½	0		
XVIII.						
Hutton Roof Moor	24	14	32½	C 13	57670·1	57668·4
Clougha Pike	74	30	56	C 15	24571·1	24570·8
Lancaster Church*	81	14	31½	0		
XIX.	[−18″]					
Ingleborough	19	51	46	C	(67990·3	67990·0)
Warton Crag	51	54	28	C 11	29352·5	29352·7
Farleton Knot......	108	13	46	T 10		

* The distance from Lancaster Church Tower to Ingleborough, calculated with the included angle and sides at Warton Crag, Farleton Knot, and Hutton Roof Moor, will be respectively 97200·8, 97198·4, 97195·5; mean 97198·2. The *calculated* angles between the church and these stations at Ingleborough will be 21° 8′ 44½″, 41° 0′ 27″, and 34° 4′ 16″. (See Triangles XIII., XV., and XVII.) The distance from the Calf to Lancaster Church Tower, calculated with the included angles and sides at

XX.	[−10″]			
Clougha Pike	20° 47′ 31″	C	(46940·3	46944·0)
Farleton Knot......	34 35 15	T 6	29353·0	29352·7
Warton Crag	124 37 14	C		

XXI.	[+ 36″ (divided between the two larger angles.)]			
Clougha Pike	4 24 53	C	(59144·0	59144·6)
Farleton Knot......	26 37 44	C & T	10157·3	10155·4
Hutton Roof Moor	148 57 23	T		

XXII.	[+18″]			
Warton Crag	19 59 32	C	26031·8	
Farleton Knot......	61 12 56	T	10154·8	10155·4
Hutton Roof Moor	98 47 32	T 6		

XXIII.				
Clougha Pike	17 18 6½	C 6	24885	
Lancaster Church	83 44 22	0	7447	
South spring of east side of the arch of the Bridge N. W. of Aqueduct...	78 57 31½	C 14		

With the included angle at Clougha Pike 105° 57′ 1″, and the sides 24885 and 81529·8, we get 91550 feet, the distance from Ingleborough to the Bridge.

XXIV.				
Clougha Pike	17 16 21½	C 6	24821·5	
Lancaster Church	83 16 38	0	7421·	
Aqueduct Bank...	79 27 0½	C 14		

With the included angle at Clougha Pike 105° 58′ 46″, and the sides 24821·5 and 81529·8, we have 91528·4, the distance from Ingleborough to the Aqueduct Bank.

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the same stations, will be, respectively, 131629, 131631, 131629; mean 131629·6 feet. The (observed) included angle at Ingleborough and the sides 97198·1 and 77614·5 feet form the following triangle:

The Calf.........	47° 7′ 27″	—	131629 feet.
Ingleborough.......	97 3 38	—	97198 —
Lancaster Church...	35 48 55		

According to Mudge, the errors of these angles will be +18″, +9, and −27″. The excess of the first distance is 23½ feet, and that of the second 24 feet.

XXV.	[+11½″]			
Clougha Pike	24° 40′ 25″	C 21	35596·4	35593·8ft.
Warton Crag	45 30 35½	C 15	20830·2	
Hest Breakwater Pole...........	109 48 59½	C 10		
XXVI.				
Clougha Pike	45 28 7½	C 17	35593·0	35593·8
Farleton Knot......	30 29 34	C 14	50003·0	
Hest Breakwater Pole...........	104 2 18½	0		
XXVII.	[+19½″]			
Clougha Pike	49 52 54	C 19	35592·0	35593·8
Hutton Roof Moor	36 55 50½	C 17	45299·0	
Breakwater Pole...	93 11 15½	C 12		
XXVIII.	[+39″ (divided between the two greater angles)]			
Warton Crag	4 59 52	C 17	22222·0	
Hest Breakwater Pole...........	124 2 48	t 5	2336·5†	
Hest Wall	50 57 20	t 3		
† 2339·3 by the base on Hest Sands. (See vol. v. page 267.)				
XXIX.				
Clougha Pike......	56 53 41	C & T	158949·5	(See Triangle XI.)
Farleton Knot......	98 1 22	T 8	134463·0*	
Black Comb.........	25 4 57	0		

* With the included angle 5° 23′ 20″ at Ingleborough, and the sides 67999 and 201970, we have 134458·4 feet for the same distance.

With the included angle 1° 23′ 56″ at Ingleborough, and the sides 61512·5 and 201970, we get 140482 feet for the distance from Hutton Roof Moor to Black Comb.

With the included angle 145° 8′ 20″ at Warton Crag, and the sides 22222 and 26031·8, we get 46052 feet for the distance from Hest Wall to Hutton Roof Moor.

With the included angle 165° 7′ 58″ at Warton Crag, and the sides 22222 and 29352·7, we have 51149 feet for the distance from Hest Wall to Farleton Knot.

With the included angle at Hutton Roof Moor 90° 30′ 22″, and the sides 365 and 10155·4, we get 10165 feet for the distance from Farleton Knot to the highest point of Hutton Roof Moor.

Bearings from the Station on Ingleborough.

Boulsworth Hill	153° 53′ 40″
Clougha West Pike	232 14 47
Rossal Landmark	237 40 35
Lancaster Church	244 27 13
Aqueduct Station	247 21 32
Aqueduct Bridge	247 23 48
Warton Crag	265 36 4
Hutton Roof Moor	278 31 20
Black Comb	279 55 19
Farleton Knot	285 27 39
The Calf	341 30 51
Centre of the Tower	264 40 9

*** South = 180°; West, 270°; North, 360°; East, 90°.

Remarks.—In the triangles I. to VI. the distances to Ingleborough derived from the first base line agree to a foot with those obtained by the second, and give the distance from the Calf to Rossal Landmark (nearly 38 miles,) equally correct. With regard to the distance to Lancaster Church tower, of which my measurement appears to be 24 feet in excess, it may be viewed either as a base of verification, proving my distances to be in excess at the rate of 1 in 4000; or, if my signal is placed 5 feet too much to the northward, and the Colonel has observed the north-east *angle* of the church tower, then will the error be reduced to $3\frac{1}{2}$ feet*.

[To be continued.]

* In the course of the operations the following distances were obtained from horizontal angles by the theodolite:

	° ′ ″	Feet.		° ′ ″	Feet.
Clougha Pike	84 40 55	103,336	Warton Crag.....	82 4 12	69,331
Farleton Knot	60 23 29	118,345	Breakwater Pole ..	80 41 1	69,586
Walney Lighthouse.			*Ulverston Church.*		
Clougha Pike	63 53 37	103,354	Warton Crag.....	102 7 11	32,372
Warton Crag	89 5 46	92,821	Hest Wall........	47 29 0	42,941
Walney Lighthouse.			*Inn at Grange near Cartmel.*		
Clougha Pike	81 55 16	102,947	Warton Crag.....	97 7 24	32,350
Farleton Knot	62 16 12	115,151	Breakwater Pole ..	52 15 52	40,590
Highest S. turret of Peel Castle.			*Grange Inn.*		
Clougha Pike	61 7 58	102,948	Warton Crag	155 47 29	16,883
Warton Crag	91 45 7	90,199	Farleton Knot....	8 47 38	45,283
Peel Castle.			*Flagstaff on Bolton-le-Sands Church Tower.*		
Warton Crag	87 4 0	69,361	Warton Crag	9 21 0	16,883
Hest Wall........	74 54 48	71,743	Hest Wall........	26 14 24	6,204
S.E. angle of Ulverston Church Tower.			*Bolton Church.*		

XLIII. *An Abstract of the essential Principles of* M. Cauchy's *View of the Undulatory Theory, leading to an Explanation of the Dispersion of Light; with Remarks. By the Rev.* Baden Powell, *M.A., F.R.S., Savilian Professor of Geometry, Oxford.*

[Continued from p. 193, and concluded.]

HAVING thus obtained the expression which establishes a general relation between the length of a wave and the velocity of its propagation, or the time of its transmission, or, again, (which is the same thing,) the time of the vibration of a molecule, we might proceed at once to certain more particular inferences; but it may be useful, perhaps, here to premise a remark or two on the general nature of the inquiry respecting the theory of dispersion.

The unequal refrangibility of the primary and component parts of which ordinary light is constituted, is a general fact, of which, as yet, no plausible explanation has been proposed, and which has presented great difficulties to any theory. These difficulties have, indeed, been triumphantly held forth by the opponents of the undulatory theory as absolutely fatal to its claims; but the truth is they are by no means *peculiar* to this theory. The hypothesis of emission has not been at all more successful in affording any satisfactory explanation.

Let us, however, look at the nature of the difficulty as it occurs upon the ordinary hypothesis of undulations. The front of a wave incident obliquely on the surface of a transparent medium, and arriving successively, *e.g.* at any two points of the surface, at each originates a new spherical wave within the medium. If the refractive power be greater, these are propagated with diminished velocity. The second of these new waves within the medium has propagated itself a little way before the first has gone through the same space as the original wave in the same time. Hence the plane touching their contemporaneous surfaces will be inclined to the surface of the medium at a less angle than the front of the original wave; and (it is easily seen) precisely so much so, as that the ratio of the sines is that of the velocities, or is equal to the index of refraction.

The refraction, then, depends *solely* on the diminished *velocity* of propagation of the waves, and ought to be exactly the *same for waves of all lengths*, unless there could be shown any *connexion* between the *length* of a wave and the *velocity* of its propagation.

"It is particularly to be remarked," observes Prof. Airy,

"that the difference of velocity does not depend on the *magnitude* of vibration of each particle, for it is the same whether the light be feeble or intense, that is, whether the vibration be small or great. Nor does it depend on the relative vibration of two contiguous particles, as that varies in the same proportion as the last, with a variation of the intensity. The only element which in conjunction with either of these will define the undulation, is the *time* of vibration: and it is, in fact, the *time* of vibration which distinguishes the different kinds of light. It would seem natural, therefore, to seek for an explanation of the difference of velocities in something which depends not on space but on time."

These observations occur in the appendix to the author's profound paper on the double refraction of quartz in the Cambridge Transactions 1831; and thus far are perfectly general, and explain in the clearest manner the precise point to which our investigation ought to be directed in any attempt to remove the difficulty of the unequal refrangibility.

These remarks, indeed, are introductory to a particular suggestion for explaining the difficulty, thrown out by the distinguished author. But it is not here intended to discuss this and other conjectural causes which have been proposed, and which may very possibly conspire to account for the result.

The essential point aimed at in any legitimate inquiry of this nature is to show some relation between the *length* of an undulation and the *velocity* of its propagation; or in other words, that in transparent media the velocity of propagation of the waves is different for the different primary rays, that is, for rays in which the lengths of the undulations are different.

But, as we have seen, in the ordinary view of the theory of waves the *equal* refrangibility of all rays is a necessary consequence. The course, then, to be pursued by any judicious inquirer, and that, in fact, adopted by M. Cauchy, is that of reviewing the first elements of the theory, viz., the particular constitution of the hypothetical æthereal medium, and endeavouring so to modify them, that while they shall apply equally to the conclusions deduced on the ordinary principles, and referring to the other phænomena of light, they shall also be made to include results which will explain the phænomena in question. Now, the great desideratum, the establishment of a relation between the length of a wave and the time or velocity of its propagation, is supplied, as M. Cauchy has expressly remarked, "*in general*," in the formula before given.

But, as was remarked at the beginning of these papers,

some more particular considerations have been lately suggested as to certain conditions which are necessary to be observed in order to the full application of M. Cauchy's principle. In fact, it becomes necessary to inquire into the more particular nature of the relation he has established. To proceed, then, to this inquiry, we will resume the simple expression which gives the relation between the length of a wave and the velocity of its propagation, viz.

$$\Omega = \frac{l}{\mathrm{T}} = \frac{s}{k}.$$

The particular nature of the relation depends on the value of s; and for the inquiries to which we refer, it will be important to have before us the value of s, or of $\frac{s}{k}$, expressed in such a form as can be subjected to examination, so that we may determine whether it fulfills the conditions presently to be described. For this purpose, then, we must briefly deduce such a value of $\frac{s}{k}$.

The value of s^2 depends upon the quantities L, M, &c., which enter into the equation (29.); and the expressions which these letters were assumed to represent are all of a similar nature, consisting of the sums of products of several factors. Taking a single term of the sum, these factors may be thus simplified:

From the assumption (22.) derived from the original equations (12.), we have

$$\mathrm{L} = \left\{ \begin{array}{l} \quad \left\{ \frac{2\,m\,\mathrm{f}(r)}{r} \sin^2 \left(\frac{k\,r\cos\delta}{2}\right) \right\} \\ + \left\{ \frac{2\,m f(r)}{r} \cos^2 a \sin^2 \left(\frac{k\,r\cos\delta}{2}\right) \right\}, \end{array} \right.$$

which is easily reducible to

$$\mathrm{L} = 2\,m\,\frac{\mathrm{f}(r) + \cos^2\alpha\, f(r)}{r} \,.\, \sin^2 \frac{k\,r\cos\delta}{2};$$

and on dividing by k^2, we may put the expression into the form

$$\frac{\mathrm{L}}{k^2} = m\,\frac{\mathrm{f}(r) + \cos^2\alpha f(r)}{r} \cdot \frac{r^2\cos^2\delta}{2} \cdot \left\{ \frac{\sin\frac{k\,r\cos\delta}{2}}{\frac{k\,r\cos\delta}{2}} \right\}^2.$$

Again, on looking at the values of the other coefficients

M, N, &c., it will readily appear that they differ only in the particular form of the products of the cosines of α, β, γ, and are all reducible to forms similar to that just given for L; that is to say, on dividing by k^2, reducible to a coefficient which shall be a function of m, r, and the cosines; and a second factor, which is identical with that involving k, r, and $\cos\delta$: in other words, resolvable into two factors, one of which involves k, and the other does not, but only quantities dependent on the nature of the medium, and not variable with a variation in k.

Thus, designating for brevity the last term by

$$\phi\,(k, r, \cos\delta)$$

and the former by $\quad \mathrm{F}\,(m, r, \alpha, \text{\&c.})$,

we shall have

$$\frac{\mathrm{L}}{k^2} = \mathrm{F}\,(m, r, \alpha)\,.\,\phi\,(k, r, \cos\delta)$$

$$\frac{\mathrm{M}}{k^2} = \mathrm{F}\,(m, r, \beta)\,.\,\phi\,(k, r, \cos\delta)$$

&c.

Now, if we take either of the values of s^2 from the equations (27.), as

$$s^2 = \mathrm{L} + \mathrm{R}\,\frac{\mathrm{B}}{\mathrm{A}} + \mathrm{Q}\,\frac{\mathrm{C}}{\mathrm{A}},$$

and substitute the above values of L, R, Q, we shall obtain the sums of similar terms with one common factor involving k, which may again be collected under one general form of a function of $m, r, \alpha, \beta, \gamma$. And as this is constant with respect to k, we may express it simply by a constant coefficient: and since $r\cos\delta$, is also constant for the same medium, we may include this in the constant factor, and thus reduce our expression into the simplified form

$$\frac{s^2}{k^2} = \mathrm{H}^2 \left\{ \frac{\sin\dfrac{k\,r\cos\delta}{2}}{\dfrac{k\,r\cos\delta}{2}} \right\}^2.$$

Or, again, since we have

$$k = \frac{2\,\pi}{l},$$

and for brevity writing $\cos\delta = n$, we shall have

$$\frac{s}{k} = \mathrm{H} \left\{ \frac{\sin\left(\dfrac{\pi\,r\,n}{l}\right)}{\left(\dfrac{\pi\,r\,n}{l}\right)} \right\}.$$

Now, to show that the velocity varies for waves of different lengths is the same thing as to show that the ratio $\frac{s}{k}$ is different for different values of k, that is, of l; and this we can determine from the expression in the form in which we now have it. If, for instance, from the nature of the quantities, the last factor should not vary with a change in l, then the requisite condition will not be fulfilled. Now, the variable factor expresses the ratio of a sine to its arc, and this will be very nearly constant for a variation in l if the arc be extremely small, that is, if $\frac{\pi r}{l}$ be very small; or, in other words, if the ratio of (r) the distance between two molecules to (l) the length of a wave be very small.

It follows, then, with regard to the hypothetical nature of the æthereal medium, that if the interval between two molecules be *very* much less than the length of a wave, then the velocity will not sensibly vary with the length of a wave.

In adopting the theory, then, with a view to its application to the facts, we must carefully observe the limitation thus imposed upon the primary nature of our hypothesis. It is a limitation which is perfectly admissible as regards any of the preceding deductions; and we must introduce it as an express condition, *that a relation between the velocity and the length of a wave is established on M. Cauchy's principles*, provided *the molecules are so disposed that the intervals between them always bear a sensible ratio to the length of an undulation.*

The necessity of the fulfilment of this condition was the suggestion alluded to at first, and on the nature and importance of it, I made a few remarks in the Physical Section of the British Association at the Edinburgh meeting. But the expression when reduced to this form presents for examination other points of still higher interest.

The existence *in general* of a relation between the length of a wave and the velocity of its propagation (as already observed,) assigns a reason why rays whose waves are of different lengths should be unequally refracted. But it becomes important, with a view to the more exact comparison of theory and observation, to be able to assign *a more specific* relation. Indeed *the theory will be incomplete unless* it enable us to show not only that *some* relation subsists between the length and the velocity of a wave, which shall vary both for each different ray and each different medium, but also that it is such as shall explain why the several rays are unequally

refracted, *in the precise degree* which prismatic observations indicate.

This inquiry, of some difficulty but of the highest interest, whichever way it may turn out, I have been engaged in prosecuting, and hope soon to be able to bring the results before the public.

Meanwhile I would observe, with reference to the formula, that in deducing it from M. Cauchy's theory, I by no means intend to affirm that it cannot be deduced on any other principles. I have, in fact, heard it stated that an equivalent expression may be obtained on less complicated considerations. It must, however, be allowed that no such deduction *has been* specifically made: and any mathematician who would make it, would be conferring a vast benefit on this branch of science, if, indeed, it should be found to stand the test of comparison with exact observations; if it should not, it will become the only course to attempt some further modification of first principles until we can deduce an expression which will represent the law of nature.

XLIV. *On the Analytical Determination of the Laws of transmitted Motion. By the Rev.* JAMES CHALLIS, *M.A.**

IN the Report on the Analytical Theory of Hydrostatics and Hydrodynamics which is printed in the second volume of the Transactions of the British Association, I have ventured, under a persuasion that the cause of scientific truth might be benefited, to express some doubt of the accuracy in principle of the received method of determining the nature of transmitted motion. The question will be allowed to be an important one by all who have turned their attention to this part of the application of analysis; but as it is somewhat of an abstruse nature, I fear that what is there said may not be perfectly understood without further illustration. For this reason I propose in the present communication to adduce a simple instance, which may serve to exhibit both the received method, and that which, as I conceive, ought to be substituted in the place of it.

The instance here selected is that of the transmission of motion along an elastic chord fixed at both ends: this will answer the purpose intended as well as an instance of transmission of motion in fluids. Let the chord in a state of rest be in a horizontal straight line; and at any position between the two extremities, let a limited portion, equal in length to

* Communicated by the Author.

$2l$, be deranged from its quiescent state and put into any arbitrary shape, subject, however, to the condition that each point is very little removed from the place it would have had at rest, and no two consecutive elements of the chord make a large angle with each other. The deranged portion being held a while in its new position, it is required to find what will ensue when it is left to itself. Let y be the distance of any point of it from the horizontal line in which the chord rests, and x the distance of the same point, measured horizontally, from the *middle* of the derangement, t the time measured from a given instant. The known partial differential equation applicable to this case is

$$\frac{d^2 y}{d t^2} = a^2 . \frac{d^2 y}{d x^2},$$

where $a^2 = \sqrt{2 g c}$, g being the measure of the force of gravity, and c the length of the chord whose weight measures the tension. The integral of this equation is

$$y = \mathrm{F}(x - a t) + f(x + a t), \qquad (1.)$$

from which is derived

$$\frac{dy}{dt} = - a \mathrm{F}'(x - a t) + a f'(+x + a t), \qquad (2.)$$

an expression for the velocity in a direction perpendicular to the horizontal line of abscissæ. We may consider it as proved by Lagrange, that in assigning any particular forms to the functions which express the initial magnitudes of y and $\frac{dy}{dt}$, we are at liberty to take only such values of them as correspond to values of x lying between arbitrary limits, and may suppose the forms of the functions to be quite different for different intervals along the line of abscissæ. Hence the equations (1.) and (2.) will apply to the case of derangement supposed above, and we may say, for instance, that the deranged portion of the chord shall take the form given by the equation $y = h\left(1 - \frac{x^2}{\varrho^2}\right)$ from $x = -l$ to $x = +l$, without considering any of the values of y that result from other values of x. The kind of motion that takes place when the chord is abandoned to itself would be inferred as follows, according to the received method, an instance of which may be seen in the Treatise on Sound in the *Encyclopædia Metropolitana*, Arts. 57—65.

Let t be dated from the instant the motion commences, and

let $\phi(x)$ be the function that represents the initial values of y. Then at the beginning of the motion,

$$\phi(x) = \quad F(x) + f(x)$$
$$0 = -a\,F'(x) + af'(x).$$

Hence $F'(x) = f'(x)$; and as $\phi'(x) = F'(x) + f'(x)$, it follows that $\phi'(x) = 2\,F'(x)$, and $\phi(x) = 2\,F(x)$. So also $\phi(x) = 2f(x)$. Hence $F(x-at) = \frac{1}{2}\phi(x-at)$, and $f(x+at) = \frac{1}{2}\phi(x+at)$. Thus it is inferred, from the equation $y = F(x-at) + f(x+at)$, that

$$y = \tfrac{1}{2}\phi(x-at) + \tfrac{1}{2}\phi(x+at).$$

As in the first instance the values of $\phi(x)$ are restricted to those corresponding to values of x from $-l$ to $+l$, no other values of this function are in any case to be taken. Hence as soon as $x+at$ becomes greater than l, the function $\phi(x+at)$ must be considered evanescent, and the function $\phi(x-at)$ alone applies. The motion at any point commences when $x-at = l$, or $t = \frac{x-l}{a}$, and ends when $x-at = -l$, or $t = \frac{x+l}{a}$. As $x-l$, the distance between the point in question and the extreme point of the initial derangement, is equal to at, it follows that the velocity of transmission in the positive direction is a. Analogous reasoning may be employed to show that there is a transmission of equal velocity in the negative direction, the function $\phi(x+at)$ being alone applicable when $x-at$ is a negative quantity greater than l.

It will be seen that in the above process, after supposing (which is permitted,) the initial values of y to be expressed by $F(x) + f(x)$, it is assumed that its values at any subsequent period are expressed by $F(x-at) + f(x+at)$, the forms of the functions F and f being the same in both cases: in other words, it is assumed that the forms of these functions do not change *with the time.* But this is a *consequence* of the uniform transmission, and cannot, therefore, be assumed in the proof of it. Whenever the velocity of propagation happens to be uniform this method leads to no error, because it rests on a supposition which implies a uniformity of propagation. It could not, however, be applied without error to an instance of propagation like that of waves at the surface of water, where the forms of the propagated waves, though dependent on the initial state of the fluid, are continually changing with the time. It is with reference to this point that, in the Report, I have suggested for consideration, whether the arbitrary functions obtained by the integration of the differential equation can be immediately applied to any but the initial

state of the fluid; and whether, previously to their application at any subsequent epoch, the law of transmission must not be first deduced by means of the quantities which the arbitrary functions involve.

The means of meeting the difficulty stated above will, I conceive, be furnished by obtaining in an independent manner a general expression for the velocity of the propagation of motion, analogous to the expression $\frac{ds}{dt}$ for the velocity of motion itself. The employment of such an expression for the determination of the velocity of propagation is the principal feature of the method I am about to propose *.

The following reasoning, which is in part the same as that in p. 253 of Professor Airy's Mathematical Tracts (2nd edit.), will answer the purpose we have in view. Let $y = \phi(x, t)$, as it must be some function of x and t. Suppose any given value of the ordinate to be carried through space with the velocity v during the small time τ. In general v will be a function of x and t; but we may suppose it constant during the time τ, and for a small portion δx of the axis of abscissæ, because by this supposition only quantities of the order τ^2, $\tau \delta x$, and above, will be neglected. Hence for the same small interval of time, the function ϕ, as far as it relates to the small portion δx of the line of abscissæ, may be considered invariable. Consequently,

$$y = \phi(x, t) = \phi(x + v\tau, t + \tau)$$
$$= y + \frac{dy}{dx} v\tau + \frac{dy}{dt}\tau + \&c.$$

Hence when τ is indefinitely diminished, $\frac{dy}{dx} v + \frac{dy}{dt} = 0$, and $v = -\frac{\frac{dy}{dt}}{\frac{dy}{dx}}$. This is the formula it was required to obtain. It is of very general application, and will serve either to find v in terms of x and t, when y is given a function of these variables, or when v is given in like manner, to find y by integration. If the formula be applied to such an equation as $y = \frac{F(x - at)}{x}$, the x in the denominator may be

* I have obtained a like formula in the Philosophical Magazine and Annals, N.S, for May 1830, (vol. vii. p. 325,) with particular reference to the propagation of motion in a compressible elastic fluid.

considered constant, when it is required to ascertain whether the function F varies with the time.

In applying the formula to find v from the equation

$$y = \mathrm{F}(x-a\,t) + f(x+a\,t),$$

a value is obtained which is dependent on the arbitrary functions, and consequently leads to no general law of transmission. There is, however, an analytical circumstance to be now attended to which has an important meaning with respect to the motion. The given differential equation is satisfied by each of the equations $y_1 = \mathrm{F}(x-a\,t)$, $y_2 = f(x+a\,t)$, and also by the equation $y_1 + y_2 = \mathrm{F}(x-a\,t) + f(x+a\,t)$, which shows that the motion corresponding to the last equation is compounded of the motions corresponding to the other two. Now, from $y_1 = \mathrm{F}(x-a\,t)$, $\frac{d\,y_1}{d\,t} = -a\,\mathrm{F}'(x-a\,t)$, and $\frac{d\,y_1}{d\,x} = \mathrm{F}'(x-a\,t)$. Hence $v = a$. So from $y_2 = f(x+a\,t)$, $v = -a$. These results, it must be observed, are obtained without reference to any particular derangement, and independently of the time; and the general inference from them is, that whatever be the initial derangement, the motion which is taking place at each point at any time results either from a propagation in a single direction, or from two propagations in opposite directions, and that the law of propagation is such that the ordinates existing at any instant are transferred through space undiminished with the uniform velocity a. It results from this law that the functions F and f do not change with the time. Had we obtained a variable rate of propagation, these functions would not have applied to the motion at two epochs separated by a *finite* interval, without first ascertaining from the law of propagation the change they undergo during that interval.

This being premised, with the help of what Lagrange has proved respecting the discontinuity of the motion, we are prepared to go strictly through the reasoning by which it was before shown that $y = \frac{1}{2}\,\phi\,(x-a\,t) + \frac{1}{2}\,\phi\,(x+a\,t)$; and it is to be observed that this equation will give the value of y at *any* distance from the origin and at any time, if both $x+a\,t$ and $x-a\,t$ be subject to the condition of lying between $-l$ and $+l$, and either function be supposed evanescent when this condition is not fulfilled: also l may be of any magnitude.

The rest of the reasoning by which it is commonly shown that the velocity of propagation is a, is open to the objection of making the determination of this velocity depend on the

initial arbitrary discontinuity of the motion. The general proposition proved above renders it unnecessary to have recourse to this method.

To complete this subject it will be proper to determine what takes place when the propagated motion reaches the fixed extremity of the chord. Suppose two propagations to take place in opposite directions, being exactly like in every respect excepting that the ordinates in one are of a contrary sign to those in the other. The point where the opposite propagations meet, being affected by equal and opposite motions, will remain constantly at rest. Nothing will be altered if this be supposed a fixed point, and the portion of the chord on one side be removed. We have then the case of a propagation reflected from a fixed extremity of the chord, and the manner in which it will take place is easily inferred from these considerations. This proposition being proved, the principles advocated in this paper, suffice for solving all the questions commonly proposed respecting the vibrations of elastic chords.

Papworth St. Everard, Jan. 19, 1835.

XLV. *Experimental Researches in Electricity.—Eighth Series. By* Michael Faraday, *D.C.L. F.R.S. Fullerian Prof. Chem. Royal Institution, Corr. Memb. Royal and Imp. Acadd. of Sciences, Paris, Petersburgh, Florence, Copenhagen, Berlin, &c. &c.*

[Continued from p. 182.]

¶ ii. *On the Intensity necessary for Electrolyzation.*

966. It became requisite, for the comprehension of many of the conditions attending voltaic action, to determine positively, if possible, whether electrolytes could resist the action of an electric current if beneath a certain intensity? whether the intensity at which the current ceased to act would be the same for all bodies? and also whether the electrolytes thus resisting decomposition would conduct the electric current as a metal does, after they ceased to conduct as electrolytes, or would act as perfect insulators?

967. It was evident from the experiments described (904. 906.) that different bodies were decomposed with very different facilities, and apparently that they required for their decomposition currents of different intensities, resisting some, but giving way to others. But it was needful, by very careful and express experiments, to determine whether a current

could really pass through, and yet not decompose an electrolyte (910.).

968. An arrangement (fig. 12.) was made, in which two glass vessels contained the same dilute sulphuric acid, sp. gr. 1·25. The plate *z* was amalgamated zinc, in connexion, by a platina wire *a*, with the platina plate *e*; *b* was a platina wire connecting the two platina plates P P′; *c* was a platina wire connected with the platina plate P″. On the plate *e* was placed a piece of paper moistened in solution of iodide of potassium: the wire *c* was so curved that its end could be made to rest at pleasure on this paper, and show, by the evolution of iodine there, whether a current was passing; or, being placed in the dotted position, it formed a direct communication with the platina plate *e*, and the electricity could pass without causing decomposition. The object was to produce a current by the action of the acid on the amalgamated zinc in the first vessel; to pass it through the acid in the second vessel by platina electrodes, that its power of decomposing water might, if existing, be observed; and to verify the existence of the current at pleasure, by decomposition at *e*, without involving the continual obstruction to the current which would arise from making the decomposition there constant. The experiment, being arranged, was examined, the existence of a current shown by the decomposition at *e*, and then left with the end of the wire *c* resting on the plate *e*, so as to form a constant metallic communication there.

969. After several hours, the end of the wire *c* was replaced on the test paper at *e*: decomposition occurred, and *the proof* of a passing current was therefore complete. The current was very feeble compared to what it had been at the beginning of the experiment, because of a peculiar state acquired by the metal surfaces in the second vessel, which caused them to oppose the passing current by a force which they possess under these circumstances (1040.). Still it was proved, by the decomposition, that this state of the plates in the second vessel was not able entirely to stop the current determined in the first, and that was all that was needful to be ascertained in the present inquiry.

970. This apparatus was examined from time to time, and an electric current always found circulating through it, until twelve days had elapsed, during which the water in the second vessel had been constantly subject to its action. Notwithstanding this lengthened period, not the slightest appearance of a bubble upon either of the plates in that vessel occurred. From the results of the experiment, I conclude that a current *had* passed, but of so low an intensity as to fall be-

neath that degree at which the elements of water, unaided by any secondary force resulting from the capability of combination with the matter of the electrodes, or of the liquid surrounding them, separated from each other.

971. It may be supposed, that the oxygen and hydrogen had been evolved in such small quantities as to have entirely dissolved in the water, and finally to have escaped at the surface, or to have reunited into water. That the hydrogen can be so dissolved was shown in the first vessel; for after several days minute bubbles of gas gradually appeared upon a glass rod, inserted to retain the zinc and platina apart, and also upon the platina plate itself, and these were hydrogen. They resulted in this way. Notwithstanding the amalgamation of the zinc, the acid exerted a little direct action upon it, so that a small stream of hydrogen bubbles was continually rising from its surface; a little of this hydrogen gradually dissolved in the dilute acid, and was in part set free against the surfaces of the rod and the plate, according to the well-known action of such solid bodies in solutions of gases (623. &c.).

972. But if the gases had been evolved in the second vessel by the decomposition of water, and had tended to dissolve, still there would have been every reason to expect that a few bubbles should have appeared on the electrodes, especially on the negative one, if it were only because of its action as a nucleus on the solution supposed to be formed; but none appeared even after twelve days.

973. When a few drops only of nitric acid were added to the vessel A, fig. 12., then the results were altogether different. In less than five minutes bubbles of gas appeared on the plates P′ and P″ in the second vessel. To prove that this was the effect of the electric current (which by trial at *e* was found at the same time to be passing,) the connexion at *e* was broken, the plates P′ P″ cleared from bubbles and left in the acid of the vessel B, for fifteen minutes: during that time no bubbles appeared upon them; but on restoring the communication at *e*, a minute did not elapse before gas appeared in bubbles upon the plates. The proof, therefore, is most full and complete, that the current excited by dilute sulphuric acid with a little nitric acid in vessel A, has intensity enough to overcome the chemical affinity exerted between the oxygen and hydrogen of the water in the vessel B, whilst that excited by dilute sulphuric acid alone has *not* sufficient intensity.

974. On using a strong solution of caustic potassa in the vessel A, to excite the current, it was found by the decomposing effects at *e*, that the current passed. But it had not

intensity enough to decompose the water in the vessel B; for though left for fourteen days, during the whole of which time the current was found to be passing, still not the slightest appearance of gas appeared on the plates P′ P″, nor any other signs of the water having suffered decomposition.

975. Sulphate of soda in solution was then experimented with, for the purpose of ascertaining with respect to it, whether a certain electrolytic intensity was also required for its decomposition in this state, in analogy with the result established with regard to water (974.). The apparatus was arranged as in fig. 13.; P and Z are the platina and zinc plates dipping into a solution of common salt; *a* and *b* are platina plates connected by wires of platina (except in the galvanometer *g*) with P and Z; *c* is a connecting wire of platina, the ends of which can be made to rest either on the plates *a*, *b*, or on the papers moistened in solutions which are placed upon them; so that the passage of the current without decomposition, or with one or two decompositions, was under ready command, as far as arrangement was concerned. In order to change the *anodes* and *cathodes* at the places of decomposition, the form of apparatus fig. 14. was occasionally adopted. Here only one platina plate, *c*, was used; both pieces of paper on which decomposition was to be effected were placed upon it, the wires from P and Z resting upon these pieces of paper, or upon the plate *c*, according as the current with or without decomposition of the solutions was required.

976. On placing solution of iodide of potassium in paper at one of the decomposing localities, and solution of sulphate of soda at the other, so that the electric current should pass through both at once, the solution of iodide was slowly decomposed, yielding iodine at the *anode* and alkali at the *cathode*; but the solution of sulphate of soda exhibited no signs of decomposition, neither acid nor alkali being evolved from it. On placing the wires so that the iodide alone was subject to the action of the current (900.), it was quickly and powerfully decomposed; but on arranging them so that the sulphate of soda alone was subject to action, it still refused to yield up its elements. Finally, the apparatus was so arranged, under a wet bell-glass, that it could be left for twelve hours, the current passing during the whole time through a solution of sulphate of soda, retained in its place by only two thicknesses of bibulous litmus and turmeric paper. At the end of that time it was ascertained by the decomposition of iodide of potassium at the second place of action, that the current was passing and had passed for the twelve hours, and

yet no trace of acid or alkali from the sulphate of soda appeared.

977. From these experiments it may, I think, be concluded, that a solution of sulphate of soda can conduct a current of electricity, which is unable to decompose the neutral salt present; that this salt in the state of solution, like water, requires a certain electrolytic intensity for its decomposition; and that the necessary intensity is much higher for this substance than for the iodide of potassium in a similar state of solution.

978. I then experimented on bodies rendered decomposable by fusion, and first on *chloride of lead*. The current was excited by dilute sulphuric acid without any nitric acid between zinc and platina plates, fig. 15., and was then made to traverse a little chloride of lead fused upon glass at *a*, a paper moistened in solution of iodide of potassium at *b*, and a galvanometer at *g*. The metallic terminations at *a* and *b* were of platina. Being thus arranged, the decomposition at *b* and the deflection at *g* showed that an electric current was passing, but there was no appearance of decomposition at *a*, not even after a *metallic* communication at *b* was established. The experiment was repeated several times, and I am led to conclude that in this case the current has not intensity sufficient to cause the decomposition of the chloride of lead; and further, that, like water (974.), fused chloride of lead can conduct an electric current having an intensity below that required to effect decomposition.

979. *Chloride of silver* was then placed at *a*, fig. 15., instead of chloride of lead. There was a very ready decomposition of the solution of iodide of potassium at *b*, and when metallic contact was made there, very considerable deflection of the galvanometer needle at *g*. Platina also appeared to be dissolved at the anode of the fused chloride at *a*, and there was every appearance of a decomposition having been effected there.

980. A further proof of decomposition was obtained in the following manner. The platina wires in the fused chloride at *a* were brought very near together (metallic contact having been established at *b*), and left so; the deflection at the galvanometer indicated the passage of a current, feeble in its force, but constant. After a minute or two, however, the needle would suddenly be violently affected, and indicate a current as strong as if metallic contact had taken place at *a*. This I actually found to be the case, for the silver reduced by the action of the current crystallized in long delicate spiculæ,

and these at last completed the metallic communication; and at the same time that they transmitted a more powerful current than the fused chloride, they proved that electro-chemical decomposition of that chloride had been going on. Hence it appears, that the current excited by dilute sulphuric acid between zinc and platina, has an intensity above that required to electrolyze the fused chloride of silver when placed between platina electrodes, although it has not intensity enough to decompose chloride of lead under the same circumstances.

981. A drop of *water* placed at *a* instead of the fused chlorides, showed as in the former case (970.), that it could conduct a current unable to decompose it, for decomposition of the solution of iodide at *b* occurred after some time. But its conducting power was much below that of the fused chloride of lead (978.).

982. Fused *nitre* at *a* conducted much better than water: I was unable to decide with certainty whether it was electrolyzed, but I incline to think not, for there was no discoloration against the platina at the *cathode*. If sulpho-nitric acid had been used in the exciting vessel, both the nitre and the chloride of lead would have suffered decomposition like the water (906.).

983. The results thus supplied of conduction without decomposition, and the necessity of a certain electrolytic intensity for the separation of the *ions* of different electrolytes, are immediately connected with the experiments and results given in § 10. of the Fourth Series of these Researches (418. 423. 444. 449.). But it will require a more exact knowledge of the nature of intensity, both as regards the first origin of the electric current, and also the manner in which it may be reduced or lowered by the intervention of larger or smaller portions of bad conductors, whether decomposable or not, before their relation can be minutely and fully understood.

984. In the case of water, the experiments I have as yet made, appear to show, that when the electric current is reduced in intensity below the point required for decomposition, then the degree of conduction is the same whether sulphuric acid, or any other of the many bodies which can affect its transferring power as an electrolyte, are present or not. Or, in other words, that the necessary electrolytic intensity for water is the same whether it be pure, or rendered a better conductor by the addition of these substances; and that for currents of less intensity than this, the water, whether pure or acidulated, has equal conducting power. An apparatus, fig. 12, was arranged with dilute sulphuric acid in the vessel A,

and pure distilled water in the vessel B. By the decomposition at *e*, it appeared as if water was a *better* conductor than dilute sulphuric acid for a current of such low intensity as to cause no decomposition. I am inclined, however, to attribute this apparent superiority of water to variations in that peculiar condition of the platina electrodes which is referred to further on in this Series (1040.), and which is assumed, as far as I can judge, to a greater degree in dilute sulphuric acid than in pure water. The power, therefore, of acids, alkalies, salts, and other bodies in solution, to increase conducting power, appears to hold good only in those cases where the electrolyte subject to the current suffers decomposition, and loses all influence when the current transmitted has too low an intensity to effect chemical change. It is probable that the ordinary conducting power of an electrolyte in the solid state (419.) is the same as that which it possesses in the fluid state for currents under the due electrolytic intensity.

985. Currents of electricity, produced by less than eight or ten series of voltaic elements, can be reduced to that intensity at which water can conduct them without suffering decomposition, by causing them to pass through three or four vessels in which water shall be successively interposed between platina surfaces. The principles of interference upon which this effect depends, will be described hereafter (1009. 1018.), but the effect may be useful in obtaining currents of standard intensity, and is probably applicable to batteries of any number of pairs of plates.

986. As there appears every reason to expect that all electrolytes will be found subject to the law which requires an electric current of a certain intensity for their decomposition, but that they will differ from each other in the degree of intensity required, it will be desirable hereafter to arrange them in a table, in the order of their electrolytic intensities. Investigations on this point must, however, be very much extended, and include many more bodies than have been here mentioned before such a table can be constructed. It will be especially needful in such experiments, to describe the nature of the electrodes used, or, if possible, to select such as, like platina or plumbago in certain cases, shall have no power of assisting the separation of the *ions* to be evolved (913.).

987. Of the two modes in which bodies can transmit the electric forces, namely, that which is so characteristically exhibited by the metals, and that in which it is accompanied by decomposition, the first appears common to all bodies, although it occurs with almost infinite degrees of difference;

the second is at present distinctive of the electrolytes. It is, however, just possible that it may hereafter be extended to the metals; for their power of conducting without decomposition may, perhaps justly, be ascribed to their requiring a very high electrolytic intensity for their decomposition.

987½. The establishment of a certain electrolytic intensity being necessary before decomposition can be effected, is of great importance in all those considerations which arise regarding the probable effects of weak currents, such for instance as those produced by natural thermo-electricity, or natural voltaic arrangements. For to produce an effect of decomposition or of combination, a current must not only exist, but have a certain intensity before it can overcome the quiescent affinities opposed to it, otherwise it will be conducted, producing no permanent effects. On the other hand, the principles are also now evident by which an opposing action can be so weakened by the juxtaposition of bodies not having quite affinity enough to cause direct action between them (913.), that a very weak current shall be able to raise the sum of actions sufficiently high, and cause chemical changes to occur.

988. In concluding this division *on the intensity necessary for electrolyzation*, I cannot resist pointing out the following remarkable conclusion in relation to intensity generally. It would appear that when a voltaic current is produced, having a certain intensity, dependent upon the strength of the chemical affinities by which that current is excited (916.), it can decompose a particular electrolyte without relation to the quantity of electricity passed, the *intensity* deciding whether the electrolyte shall give way or not. If that conclusion be confirmed, then we may arrange circumstances so that the *same quantity* of electricity may pass in the *same time*, in at the *same surface*, into the *same decomposing body in the same state*, and yet differ in intensity, *decomposing in one case and in the other not*. For taking a source of too low an intensity to decompose, and ascertaining the quantity passed in a given time, it is easy to take another source having a sufficient intensity, and reducing the quantity of electricity from it by the intervention of bad conductors to the same proportion as the former current, and then all the conditions will be fulfilled to produce the result described.

[To be continued.]

XLVI. *Insectorum novorum exoticorum* (*ex Ordine* Dipterorum) *Descriptiones. Auctore* J. O. Westwood, *F.L.S. &c.**

Gynoplistia, *Westw.* (*Anoplistes*†, Westw. in Zool. Journ. No. 20. ined.)

Ctenophoræ affinis. Antennæ in utroque sexu pectinatæ, ♂ 18- ♀ 17-articulatæ. Alarum nervi ut in *Ctenoph. flaveolatâ* dispositi.

Sect. 1. Antennæ ♂ articulis 3—17 unipectinatis.

Sp. 1. *Gyn. vilis.* *Ctenoph. vilis,* Walk. Ent. Mag. 2. 469. *Anoplistes nervosa,* Westw. Zool. Journ. No. 20. ined.

Habitat in Novâ Hollandiâ.—In mus. nostr.

Sp. 2. *Gyn. cyanea,* Westw. Nigra; abdomine chalybeo purpureoque nitenti; femoribus tibiisque ad basin minùs obscuris; alis obscurè nervosis, costâ maculisque duabus subcostalibus fuscis: ♀ antennis mutilatis.—Long. corp. lin. 6.

Habitat in Novâ Hollandiâ.—In mus. nostr.

Obs. A *Tipulidis* omnibus colore metallico discrepat.

Sect. 2. Antennæ ♂ articulis 3—14 unipectinatis.

Sp. 3. *Gyn. bella.* *Ctenoph. bella,* Walk. Ent. Mag. 2. 470. *Anoplistes variegata,* Westw. Zool. Journ. No. 20. ined.

Habitat in Novâ Hollandiâ.—In mus. nostr.

Sp. 4. *Gyn. annulata,* West. ♀ Nigra; thorace coxisque lætè fulvis; alis fuscis; abdomine sericie subaureâ obtecto; tibiis annulo centrali albo tarsisque basi fulvescentibus; antennis ♀ 17-articulatis, articulis 3—9 ramum brevem obtusum emittentibus, 10mo internè acutè producto, reliquis simplicibus.—Long. corp. lin. 5. Exp. alar. lin. 9½.

Habitat in Americâ Septentrionali.—In mus. D. Hope.

Ptilogyna, *Westw.*

Tipulæ affinis. Antennæ in utroque sexu pectinatæ; ♂ 13-articulatæ, ramulis 7 internis, 15 externis longis; ♀ 14-articulatæ, ramulis 7 internis, 8 externis brevibus. Alæ cellulâ discoidali subapicali 7-angulatâ, ferè ut in *Limnobiâ trisulcatâ* Schumm.

Sp. 1. *Ptilog. ramicornis.* *Tipula ramicornis,* Walk. Ent. Mag. 2. 469. *Ptilogyna marginalis,* Westw. Zool. Journ. No. 20. ined.

Habitat in Novâ Hollandiâ.—In mus. nostr.

Ozodicera, Macq. Dipt. p. 92. (*Hemicteina,* Westw. in Zool. Journ. No. 20. ined.)

Sp. 1. *Ozod. pectinata,* Wied. (*Ozod. ochracea,* Macq. loc. cit.)

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* Communicated by the Author.

† I have been compelled to alter this name and that of *Ozocera,* proposed by me for two Tipulideous genera in a memoir forwarded several years since for publication in the Zoological Journal, (and which has been printed off nearly twelve months,) M. Serville having in the mean time employed *Anoplistes* for a genus of longicorn beetles, and M. Macquart that of *Ozodicera* for a genus of *Tipulidæ* for which in the same memoir I had proposed the name of *Hemicteina.* The specific names of several of the insects described in the same memoir will also sink into synonyms, Mr. Walker having published a description of them in the Entomological Magazine for January 1835. In like manner my *Aschiphasma annulipes* will sink into a synonym of *Perlamorphus hieroglyphicus* of Mr. G. R. Gray's monograph upon the *Phasmidæ,* just published. The great convenience arising from the publication of scientific works at short intervals, such as the Philosophical Magazine, is thus especially evidenced.

Sp. 2. *Ozod. gracilis*, Westw. Fusco-ochracea; rostro subfulvo; antennis fuscis, basi ochraceis; thorace subvittato; alis subfumosis, nervis stigmateque ochraceis.—Long. corp. lin. 10. ♂.

Habitat in Brasiliâ.—In mus. nostr.

Cerozodia, *Westw.* (*Ozocera*, Westw. Zool. Journ. No. 20. ined.—nec *Ozodicera*, Macq.)

Limnobiæ affinis. Antennæ thorace paulò longiores, articulis 32; 3—31, ramulum longum emittenti. Palpi perbreves. Alarum nervi ut in *Gynoplistiâ vili* dispositi.

Sp. 1. *Cer. interrupta*, Westw. Ochracea; ramulis antennarum subfuscis; alis maculis 4 parvis discoidalibus longitudinaliter collocatis, cinereis.—Long. corp. lin. 10. In mus. D. Hope.

Habitat in Australiâ apud "Swan River."

Bittacomorpha, *Westw.*

Genus anomalum *Tipulariis terricolis*, Latr., evidenter pertinens. Caput et thorax parva. Abdomen valdè elongatum et depressum. Pedes longitudine mediocres; femoribus tibiisque gracilibus; tarsis basi dilatatis densè ciliatis. Alæ nervis perpaucis, ferè ut in genere *Sciophilâ* dispositis. Antennæ graciles, filiformes. Palpi capitis longitudine, articulis 4 æqualibus. Lobi labiales magni. Ocelli 0?

Sp. 1. *Tipula clavipes*, Fab. Sp. Ins. 2. 404. *Ptychoptera clavipes*, Fab. Syst. Rhyng. Wied. Auss. Zweifl. Ins. 1. 59.—Long. corp. lin. 8. Exp. alar. lin. 8¼.

Habitat in Americâ Boreali. In Insulâ Newfoundland.—In mus. nostr. —Commun. Dom. Churton.

Midas *maculiventris*, Westw. Obscurè niger; abdomine testaceo-fuscanti, segmentis apice pallidis et (nisi segmentis duobus basalibus) maculâ triangulari obscurâ in medio notatis; hæ maculæ versus apicem abdominis magnitudine crescunt: segmento anali fusco; abdomine toto subtùs concolori; alis flavido-fuscantibus, regione nervorum internorum colore obscuriori tinctâ.—Long. corp. lin. 11. Exp. alar. lin. 19.

Hab. ?—In mus. nostr.

Midas *auripennis*, Westw. Niger; capite cum antennis, pedibus (nisi basi femorum) abdomine (nisi segmento basali marginibusque terminalibus segmentorum 2 et 3,) lætè luteis; alis auricoloribus, maculâ versus apicem costæ nigrâ, margineque interno pallido, mesosterni lateribus unispinosis. Alarum nervorum directio *Midasibus veris* paulò discrepat.—Long. corp. lin. 11. Exp. alar. lin. 19.

Habitat in Novâ Hollandiâ. In mus. Hope et nostr.

Midas *viduatus*, Westw. Niger; faciei thoracisque lateribus, et maculâ triangulari utrinque ad basin segmentorum 3 et 4 abdominalium, sericie argenteâ obtectis; alis pallidis in medio fuscantibus, nervis fuscis.—Long. corp. lin. 10. Exp. alar. lin. 16.

Habitat in Novâ Hollandiâ.—In mus. nostr.

XLVII. *On an unusual Affection of the Eye, in which three Images were produced. By* D. Griffin, *Esq.**

The following affection of the eye is, I believe, a very unusual one. I have seen no account of such a phænomenon in any of the writings on the physiology of vision, and

* Communicated by the Author.

shall feel gratified if I can learn whether it has ever been observed by others.

One day in the early part of last July, after having spent a considerable time in looking at various land objects through a telescope, I perceived a very great indistinctness of vision after I had left off, which I soon found existed entirely in the left eye. I had kept this eye closed while I was at the telescope; and having often observed before that some indistinctness of vision occurred in the same circumstances, I attributed it to the weakness of sight that would naturally follow from having kept that eye unemployed while using the other, and did not mind it much at first. It seemed now, however, so great that I covered the right eye to examine the state of the other more particularly.

I then found, with some surprise, that it gave more than one image, and on directing it towards a box on the chimney-piece, about eight or nine feet from me, on the front of which were some large and extremely well printed letters, I perceived that there were three distinct images of those letters placed vertically one above the other. The lowest, which I shall call the true image, was undisturbed from its proper place. The dislocation of the second image was just so great as to make it overlap more than the upper half of the last-mentioned, and its light was scarcely, if at all, inferior to that of the true one. The light of the third was much more faint than that of either of the others, and its displacement was such as to allow it still slightly to overlap the true image at its upper edge, where the combination of the three images produced a dark line along the letters exactly similar in appearance to overlying shadows. There was not the least displacement towards either side, unless I changed my head from an erect position; and I could not find any trace of a fourth image by the closest examination. This affection lessened gradually in the course of the evening, the false images slowly descending to their true place, and next day that eye was as perfect as the other.

I was for some time puzzled to account for this strange appearance. It seemed difficult to suppose that any functional derangement of the retina could give origin to three images so distinct and separate; and though a double image is sometimes an attendant upon amaurotic affections of the eye, yet this, so temporary in its nature, could hardly be classed with such complaints. The cleanness and good definition of the images seemed to indicate some optical change; and besides this, the distortion occurring all in one plane evidently pointed to some single cause, and that probably a mechanical one, as the origin of the whole phænomenon.

The effect, however, produced was such as would result from a distortion or bending back of the upper part of the crystalline lens, producing an effect not exactly like spherical aberration, but like what would arise from the axis of that part of the lens losing its parallelism to the axis of the centre and other parts, which would tend to throw the image produced by that part in the direction in which the distortion of the axis lay.

In order that a correct idea may be formed of the degree of the displacement, it is necessary to mention that the letters which I looked at, at the distance of three yards, and of which the different images were separated to the degree mentioned above, were about $\frac{3}{4}$ths of an inch in height and about the same in breadth.

The only thing that occurred to me that could produce such a distortion was the pressure of the upper eyelid on the eyeball, which was very considerable and long continued. That the distortion was in the lens alone seems probable, because, from its half-solid state, it is almost the only part of the eye that would retain the effect of pressure for any time; but if the altered shape of the lens was the cause, the alteration must have been an exceedingly peculiar one. To produce the three images above mentioned it must have had two sudden bendings backwards; one somewhere near the middle, and the other near the upper edge. The lower half, which I suppose to have been undisturbed, would in that case have given the true image; the part immediately above, which was bent backwards in some degree, would have formed an image lower on the retina, and therefore higher to the perception than the true one; and the highest part, or upper edge, of the lens, which was most distorted, would have given the lowest image on the retina, and therefore the highest to the perception. But here came the difficulty: on considering the structure of the lens as far as that is at present known, and how its density lessens gradually from the centre to the circumference, it seemed extremely hard to suppose that any bending could take place in it otherwise than very gradually, and in a regular curve. This gradual bending, it is evident, would not be indicated by the perception of multiplied images, but by great indistinctness and haziness in the upper part of the object; yet of either haziness or deficiency of outline in the images there was not the least appearance.

I have tried repeatedly since to produce the same appearance by simply covering the left eye while using the right, and otherwise observing the same circumstances, but I found that

the pressure of the eyelid was always essential to the success of the experiment.

I have only further to add, that I should be glad to have the opinions of those who are interested in the physiology of vision on this curious fact, as I find it exceedingly hard to conceive how such a change in the lens as I have supposed, could be produced by any pressure, however exercised, of the eyelid.

Pallas Kenry, Feb. 1, 1835. D. Griffin.

XLVIII. *On the Refraction and Polarization of Heat.* By James D. Forbes, *Esq., F.R.SS. L. & E., Professor of Natural Philosophy in the University of Edinburgh.*

[Continued from p. 214.]

§. 4. *On the Depolarization and Double Refraction of Heat by Crystals.*

46. The analogies which have hitherto guided us from the laws of light to those of heat, suggest that it is far from improbable that the influence of crystallized bodies upon polarized light, which produces the most splendid and most varied, but, at the same time, amongst the most determinate phænomena of optics, may have a counterpart in the science of heat. The simpler of these, of course, it is our object first to verify: and, to a certain extent, this is all that is necessary, in order to complete the analogy of heat and light in this particular case; for the conditions essential to their production in the case of light, are on all hands admitted to depend on the susceptibility of the principle of light to undergo certain modifications in certain circumstances, extremely limited in number, and which then produce, as necessary consequences, all the subsequent effects. If we find that heat undergoes the same changes under the same circumstances, so far as we can detect them, there is the highest probability in favour of the extended analogy; for if there be a necessary sequence in the one case, it must be inferred also in the other.

47. When polarized light is caused to pass through a crystallized body possessing the power of double refraction, it happens, in a great majority of the conditions under which the experiment may be made, that the light, on emerging from the crystal, has undergone some change. This change may, for instance, render it capable of reflection at a surface inclined to the rays of light at the polarizing angle, which they were incapable of doing before the crystal was interposed, or if be-

fore capable of reflection, they may now be partially, or wholly, incapable of it. Such a mode of action may in general terms be called *depolarization*, an expressive term, though not quite correct; or as has more lately been proposed, in conformity with the more accurate views now entertained on the subject, DI-*polarization*, indicating that the action of the interposed crystal is to separate the incident polarized ray into two parts by its doubly refracting energy; which parts are polarized in rectangular planes, and by their union produce the modified effect. But whatever be the explanation which we adopt of the curious and complicated changes which doubly refracting crystals exercise in the case of light, it is clear that the establishment of a correlative fact in regard to heat unaccompanied by light, must force us to admit an identity of the laws which combine, by a singularly refined mechanism, to produce an identical result. The theory of undulations is in fact by far the simplest that we can adopt, and it requires us, if we admit depolarization, to admit the existence of double refraction and of interference. The demonstration, then, of such a property of heat, is one of such importance, as to require the fullest proof.

48. The power of mica to depolarize heat, I discovered on the 16th of December last. If in the case of polarizing light, whether by reflection or refraction, the planes of incidence relatively to the polarizing and analysing plates be at right angles to one another, the light is wholly (or at least in great part) stopped. The plates remaining in this position, it is well known, that if a film of mica be interposed between them, so as to be perpendicular to the incident light, *that* light will no longer be stopped excepting in two positions, namely, when the Principal Section of the mica plate (or the plane containing the two axes) is parallel or perpendicular to the plane of polarization. In intermediate positions, light reaches the eye. This is true for all thicknesses of the film of mica only where light of different degrees of refrangibility is combined: with perfectly homogeneous light, at certain thicknesses, no light would in any position reach the eye, that is, it would not be depolarized.

49. The analogous fact, in heat, would of course be indicated by interposing a film of mica between a polarizing and analysing plate, having their planes of incidence inclined at right angles to one another, and observing whether any difference of heating effect appeared when the Principal Section of the plate was parallel to the plane of Primitive Polarization, or inclined 45° to it.

50. The very first experiments which I tried, seemed deci-

sive on this point. I employed the piles of mica for polarizing by transmission, and interposed successively two plates of mica so arranged that the Principal Section was in the one parallel (or perpendicular), and in the other inclined 45° to the plane of Primitive Polarization. These were cut from the same piece, and precisely of the same thickness; but I afterwards employed one and the same plate, inclined alternately in two positions. By the first experiments with *dark heat* (temperature about 700°) the polarizing mica plates (E and F) being crossed, the ratios of heat transmitted, when the principal section *coincided* with the plane of polarization (when the depolarizing effect was nothing), and when it was *inclined* 45° (when the depolarizing effect ought to be a maximum), were the following:

100 : 120   100 : 110   100 : 122   100 : 125

With different polarizing and analysing plates, viz. C and D, the following ratios were obtained also for *dark heat*:

100 : 118   100 : 120   100 : 120   100 : 113

51. We have seen that the heat of *Incandescent Platinum* is highly polarizable; it is also powerfully depolarized, as the following proportions obtained with polarizing mica plates, and the same interposed films as before, indicate, as the principal section was inclined 0° or 45:

100 : 126   100 : 138   100 : 138

52. There were two distinct interposed plates employed for these experiments; their thickness was such as to transmit the red of the second order of the Newtonian Scale, when viewed by *polarized light*, analysed at right angles to the plane of polarization. To show that no appreciable difference existed in their power of stopping *common* or unpolarized heat, and to point out the accuracy of such determinations, I may quote the following experiment on the transmission of unpolarized non-luminous heat through the two plates.

Plate with sides inclined 0° and 90° to Principal Section.	Mean.	Plate with sides inclined 45° to Principal Section.
$18\frac{1}{4}$°		
	18°·25	$18\frac{1}{4}$°
$18\frac{1}{4}$		
	17·9	$17\frac{3}{4}$
$17\frac{1}{2}$		
	18·0	18
$18\frac{1}{2}$		
	18·25	18+
18		

The reduction is performed as in art. 20. These quantities

were observed with the naked eye, and may therefore be considered as coinciding in the two columns.

53. In repeating these experiments with a *single* film of mica, which was alternately placed with its axis parallel or inclined 45° to the plane of primitive polarization, similar results were obtained. With incandescent platinum, the result is of the most striking character; under favourable circumstances, the needle moves through from 2° to 3°, (a quantity, it will be recollected, of which a twentieth or a thirtieth part is capable of measurement by the improved method of observation,) or even more, commencing the moment that the change in the position of the mica film is effected (which I generally perform with long forceps, so as to avoid the near approach of the hand to the pile). A few of the first experiments gave for the ratio of the effect on the pile in the two positions, with a *single* plate,

	138 : 100	118 : 100	116 : 100
Another series,	130 : 100	125 : 100	123 : 100
A third,	120 : 100	120 : 100	
A fourth*,	128 : 100	123 : 100	122 : 100

54. The depolarizing effect of this mica plate (which also gives by polarized light the red of Newton's second order,) upon non-luminous heat, was also exceedingly well marked, as I shall presently show, and amounted generally to between 0°·5 and 1°, as the *statical* effect; but as the source of heat requires to be closer to the mica plates, more is transmitted by conduction, which constantly tends to *diminish* the ratio of the true difference of effect, as observed in (23).

55. It occurred to me, that since thin plates of mica present comparatively little resistance to the passage of heat, a very thin plate might perhaps depolarize more heat than it stopped, and thus we should have the paradoxical effect of an interposed obstacle increasing the effect, a mode of action which I thought I perceived in a thicker plate. I was at first surprised to find the reverse the case.

56. A film of mica which transmitted a slightly blue white of the first order (by polarized light), and which was capable of polarizing light circularly (nearly), was employed for this experiment. But not only was I unable to detect any increase of effect when it was placed between the polarizing and analysing plates (E and F) *crossed* so as to give a minimum of transmitted heat, but there was an evident interception when it was interposed. In other words, it stopped more heat than it depolarized. This was true both with non-luminous heat

* Observed by Dr. Traill.

and with that from incandescent platinum. When I proceeded to estimate its depolarizing power by the usual method of placing the Principal Section at 0° or at 45°, I totally failed in obtaining a sensible effect with non-luminous heat, and with incandescent platinum it was extremely faint. My subsequent experiments gave for the proportion of the depolarizing effect to the whole heat which reached the pile when the plates E and F were crossed,

Non-luminous Heat.	Incandescent Platinum.	Argand.
·00	·016	·03

But upon performing this experiment with a thicker plate, namely, that before alluded to in (53) and (54), I found that where it was interposed between the *crossed* polarizing and analysing plates, the quantity of heat which reached the pile *was increased by that interposition* by about 0°·5. Hence we have the singular spectacle of the transmission of heat being *greater* when a thick obstacle is interposed, whilst the direct effect is actually *diminished* by the interposition of a thin one. This effect was of the most marked character with heat from incandescent platinum; with dark heat the result was quite analogous, but within narrower limits. With *unpolarized* dark heat, I found that the thin plate stopped 30 out of 100 rays, whilst the thick one stopped 65, or more than twice as much.

57. The depolarizing effect of mica was tried under every variety of circumstance, and with the most conspicuous and coincident results. The quantity of light accompanying the heat, appeared by no means to regulate the quantity of heat depolarized. The heat emitted from platinum, of a full red, (and therefore not vividly incandescent,) was one of the most favourable. Heat from an Argand lamp, with glass chimney, was also employed, and absolutely non-luminous heat from brass about 700°. I also employed mercury in an iron vessel, at about 500°, and found the results admirably marked. Pursuing the experiment as the temperature of the mercury descended, I found the effect still very sensible at 220°, and then thought of trying hot water, which I had not done since I devised the telescopic method of observing the galvanometer (6). The result was, that, by most decisive experiments, I found that *heat under 200° Fahrenheit, is capable of being depolarized by mica.* Even where I did not measure the amount, the instantaneous motion of the needle in the proper direction, when the Principal Section of the mica plate was parallel, or inclined 45° to the plane of primitive polarization, gave as strong evidence to this fact as to any other I have recorded.

58. It would be quite impracticable to give any detailed account of my experiments on depolarization within moderate compass. It may be satisfactory, however, to mention, that, upon an examination of all the experiments I have recorded, I find that (excluding those on the *thin* plate of mica mentioned in (56),) amongst 157 numerical comparisons, for the purpose of obtaining the depolarizing effect, *only one* gives a negative, and *one* a neutral result; and these exceptions occur in observations made upon heat of the lowest temperatures, namely, from mercury under 500°, and water under 200°. These experiments were made with heat from the various sources mentioned above (57), and with three different mica plates. The comparisons were always made from alternate observations, as in (20) and (52). Of these 157 comparisons, no less than 92 were made with heat wholly unaccompanied by visible light.

59. These conclusions, derived entirely by the use of mica as the depolarizing crystal, I endeavoured to confirm in the case of some others. Selenite, from the thin laminæ into which it may be split, naturally suggested itself, but I found that its interceptive power for heat is so much greater than that of mica, as to render these experiments nearly abortive. With heat from incandescent platinum, however, I got tolerably marked indications of its action.

60. With tourmaline I was more successful. Not only was I able to obtain decisive depolarization when slightly luminous heat was employed, such as that from incandescent platinum, and the principal section of the tourmaline was alternately parallel, and inclined 45° to the plane of primitive polarization, but also when dark heated brass was used (at 700°). The tourmaline was one of those marked C and D (21), not mounted on glass, and of a pale amber colour.

61. From these experiments, the depolarization, or *Di*-polarization of heat seems unquestionably established, whence admitting that it depends on the same mode of action as the corresponding facts in the case of light, which seems certain, we are bound to admit that heat (even that from warm water), is susceptible of *double refraction*, that the two pencils are *polarized in opposite planes*, and that they become capable of *interfering* by the action of the analysing plate*.

62. These results we hold to be direct conclusions from the establishment of the existence of a mode of action, of a very

* I made one attempt to obtain polarizing effects by means of Mr. Nicol's very elegant single-image calc-spar prisms, but without success, as I had anticipated, from the great proportion which the thickness of the spar necessarily bears to its aperture.

complicated character, which nothing but an acquaintance with the corresponding facts with regard to light could have taught us *how* to look for, and which, by coinciding with these, indicate a common mechanism. Hence, too, were our senses or our instruments capable of perceiving them, we should necessarily discover, by the passage of heat along the axes of doubly refracting crystals, all the elegant forms of rings and brushes, defined by heating, instead of luminous rays.

63. But this analogy may be carried still further. So definite are the experimental results in depolarization, that I thought of comparing the intensities of the effects with those produced in light; and for this purpose, our method of estimating heat is far more satisfactory than those for estimating the intensity of illumination. The fundamental law, which I felt most anxious to verify, was the complementary nature of the transmitted heat, when the *plane of analysation* is parallel, and when it is perpendicular, to the *plane of polarization*.

64. It is well known in the case of light, that when no crystal is interposed between the polarizing and analysing plates, or when the crystal has its principal section parallel or perpendicular to the plane of primitive polarization, the whole of the light is stopped* when the plates are perpendicular or *crossed*; the whole is transmitted when they are *parallel*. If the principal section of the crystal be now inclined 45° to the plane of polarization, the depolarizing effect is a maximum, a portion of light now being transmitted to the eye, the plates remaining *crossed*, which was not transmitted before, and, in like manner, a portion of the light which was formerly transmitted when the plates were *parallel* being now stopped. Now these two quantities are equal to one another, and therefore the sum of the intensities of illumination in the two cases (*plates parallel* and *plates crossed*) is a constant quantity. Now these two pencils correspond to the ordinary and extraordinary image in an analysing prism of calcareous spar. Let us call these intensities O^2 and E^2. Let the whole quantity of polarized light, or the value of O^2, when the principal plane of the crystal coincides with that of polarization, be F^2, and, under the same circumstances, $E^2 =$ zero. Then since the two effects are complementary, whatever be the position of the principal plane, $O^2 + E^2 = \text{const.} = F^2$,

and $$E^2 = F^2 - O^2;$$

or the whole intensity *gained* by the extraordinary pencil

* That is, not reflected when the light is analysed by reflection, or not transmitted when it is analysed by refraction. In these experiments the latter method was always used.

(which at first was zero), by the depolarizing influence of the crystal, is equal to that *lost* by the ordinary pencil.

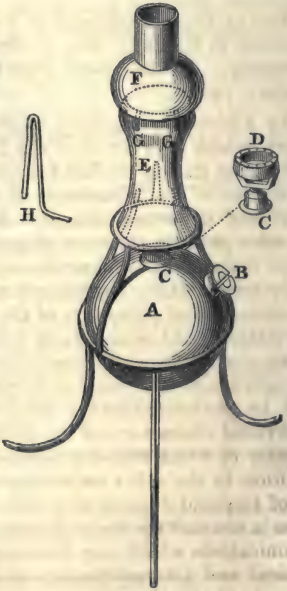
65. That the same law holds in the case of heat, the experiments, of which the following is a brief summary, seem to indicate. The coincidence has generally been more perfect, as the steadiness of the source of heat admitted of more accurate comparison. The indications in the same line are alone intended to be compared, as they are expressed in degrees of the multiplier, the absolute amount of which would vary in different experiments. The interposed film of mica No. 1. is that mentioned in (54), as giving a red of the second order when placed between the polarizing and analysing plates crossed; the film No. 2. gave a plum red of the first order under the same circumstances.

Source of Heat.	Mica Plate.	Increase of Intensity of Extraordinary Pencil, by the Depolarizing Action of the Interposed Crystal. E^2		Decrease of Intensity of Ordinary Pencil, by the Depolarizing Action of the Interposed Crystal. $F^2 - O^2$	
		Number of Comparisons.	Degrees of Multiplier.	Number of Comparisons.	Degrees of Multiplier.
Mercury below 500°	No. 2	5	0·23	6	0°·26
Brass about 700°,	No. 1	4	0·46	4	0·32
	No. 1	4	0·35	4	0·55
	No. 1	4	0·51	4	0·52
	No. 1	4	0·59	5	0·78
	No. 2	4	0·44	5	0·40
	No. 2	7	0·75	7	0·70
	Mean	27 comp.	0·517	29 comp.	0·545
Incandescent Platinum.	No. 1	3	2·12	3	2·14
	No. 1	4	2·22	4	2·52
	No. 1	4	2·01	5	2·13
	No. 2	6	2·38	6	2·50
	Mean	17 comp.	2·18	18 comp.	2·32
Argand Lamp (with chimney.)	No. 1	4	0·97	4	1·00
	No. 2	4	1·90	4	1·74
	Mean	8 comp.	1·43	8 comp.	1·37

[To be continued.]

XLIX. *Description of a new Spirit-lamp Furnace. By* ARTHUR TREVELYAN, *Esq.**

HAVING lately been engaged in following out chemical analysis under the able direction of William Gregory, M.D., Edinburgh, I found that a lamp for generating a great heat would be highly useful, and was much wanted by the analytical chemist. After experimenting to a great extent with many modifications of the lamps of Berzelius and others, I found that they all wanted power, and when used for a length of time, attained such a temperature that the spirit boiled and flowed over. After continuing these experiments for nearly three months, I had almost relinquished them in despair of success, when I accidentally became acquainted with Andrew Whelpdale, a young and promising chemist, to whom I stated my difficulty: he recommended, if it could be contrived, that the vapour of alcohol should be used. I immediately came into his view, and had a lamp constructed, of which a drawing is inclosed (see the figure). After trying it with different burners, a stop-cock and safety-valve (neither of which is necessary) and differently formed chimneys, it was brought to a state of perfection and power which we little expected. It fused liquid as water, 500 grains of bicarbonate of soda in fifteen minutes, consuming three ounces of alcohol, and I think might do it in less time, but the chimney was rather small for the size of the platina crucible used: the ends of the brass uprights attached to the rim on which the chimney stands were fused in a similar experiment.



From its great power I think it may be called emphatically the "Lamp-furnace."

It may be made of any size, but the chimney must be suited to the crucible, round which the flame should play freely.

The vapour may be generated by a spirit-lamp placed underneath the globe.

* Communicated by the Author.

My friend Dr. W. Gregory exhibited this lamp on the 11th of September to the Chemical Section of the British Association at its late meeting in Edinburgh.

Explanation of the Figure.

A. Copper globe for holding the alcohol, with bottom slightly concave to concentrate the flame of lamp placed below.

B. Opening covered with screw-cap, for introducing the alcohol; a conical safety-valve with worm spring may be attached if wished.

C. Screw shank of Argand burner.

D. Argand burner pierced with ten holes: this burner is the same as the gas burner used in Edinburgh, but with half the number of holes.

E. Copper chimney within which the crucible is to be placed.

F. Cupola, open at top.

G. Ends of wires, similar to that marked H: there are three of these with the ends inside, on which the crucible rests, bent at right angles.

L. *Reviews, and Notices respecting New Books.*

The West of England Journal of Science and Literature. Edited by George T. Clark. *No.* I. *January* 1835. *To be continued Quarterly.* Bristol. 8vo. Part I. Science, pp. 88. Part II. Literature, pp. 36.

In the Address explanatory of the intention and objects of this work, which is prefixed to the first Number now before us, it is stated "that during the last few years the tastes and pursuits of a large section of the inhabitants of Bristol have been undergoing a gradual but important change. Science and literature have become more popular, the tone of general conversation has improved, and the demand for instructive and profitable books has proportionably increased." The improvement of the City Library and the establishment and prosperity of the Bristol Institution are cited as manifestations and evidences of this change; and the consequence is drawn that a journal devoted to the encouragement and direction of pursuits which have become so generally appreciated will be supported by the inhabitants of Bristol and the neighbouring places. The physical character and the archæological interest of the extent of country of which that city is the metropolis, are brought forward in addition to the other causes out of which the prospects of the West of England Journal originate. This work is further designed to open a channel for the publication of the most valuable original communications which may from time to time be made to the Philosophical and Literary Society attached to the Bristol Institution, and eventually for that of communications made to other provincial societies. "With regard to science," it is observed, "we shall endeavour to avail ourselves of all the peculiar local advantages afforded

by the very interesting geological situation of this metropolis. Placed in the centre of a rich coal-field, and yet on the edge of the great range of the oolites, and within a few miles of the cretaceous downs of Wiltshire, on the one side, and the transition chains of the Quantocks and Exmoor on the other; we have, taking Bristol as a centre, within a circle of thirty miles, every geological formation, from chalk to transition slate. Every walk through the lovely dales which diversify our scenery, is as rich in geological interest as in picturesque beauty; and we may hope to open to our readers a new and copious source of instruction and pleasure in their daily excursions."

The means for the cultivation of Zoological science afforded by the Museum of the Bristol Institution, and the advantages which its laboratory and apparatus afford for the repetition of experiments and the prosecution of original researches, in Chemistry and in Electricity, are also enumerated among the circumstances connected with the establishment and expected support of this Journal; it being undoubted by the Editor, "that the city where, in his early life, Davy started as the assistant of Beddoes, will again yield an efficient supply of labourers in the advancement of science." The Address concludes with a statement of the objects of the work with respect to Literature, on which, however, it is not our province to enlarge.

Entertaining the best wishes for the success of the West of England Journal, and concurring altogether in the propriety of its establishment, on the grounds which we have noticed, we may now take a view of its contents. The first part of the Number, devoted to Science, commences with an "Essay Introductory to Geology, by the Rev. W. D. Conybeare." This contains, in succession, a sketch of the order of geological formations, and of the organic remains which they present, with a concise tabular view of the inferior, secondary, and tertiary rocks, a notice of the dislocations and disruptions which appear to have affected the strata, and a statement of the more obvious inferences of theoretical geology. In his next communication, (to appear in the second or April Number,) Mr. Conybeare will proceed to the local facilities which the neighbourhood of Bristol presents to the study of geology. Mr. Conybeare's synoptical table of formations is a modification of part of that given by him in the "Outlines of the Geology of England and Wales:" he makes the following remarks on the association of the carboniferous group with the transition class of rocks:

"With these [the transition rocks] it is clear that the carboniferous series of rocks must, from the close generic relation of their organic remains, both animal and vegetable, be associated as the upper group of the same order. The anthracite, or culm alternating with the roofing slates of North Devon, is in fact a true grauwacke coal formation, and closely agrees in the relics of vegetables which it exhibits, with the great coal formation*." (p. 4.)

* See our Number for January, p. 67.

In our review of Mr. Conybeare's article on the progress of geology in the Second Report of the British Association, we noticed his adoption and explanation of the views of Leibnitz, with respect to the original igneous fluidity of the nucleus of the globe, and the formation of its present crust in part from the refrigeration of the surface of this nucleus*:—proceeding with these views he now draws the subjoined inferences with respect to those entertained by the newly elected President of the Geological Society:

"This view of the subject is well illustrated, in some of the diagrams in the concluding volume of Lyell's very able elements; but he [the reader] will perhaps draw a further inference from these very representations, which that author has failed to draw; for he may see in them an evident reason why the perturbations of this igneous mass, acting in the earlier periods, when the crust which confined it was as yet in a thin and almost nascent state, and could therefore have opposed but a comparatively trifling resistance, must have produced effects incalculably superior in degree to those for which they are at present adequate, when repressed by the enormous column of resistance which the whole thickness of the actually consolidated crust at present offers. If we believe, as Mr. Lyell is most anxious that we should believe, that the laws of nature are ever permanent and uniform, we must admit it as one of the plainest of those constant laws, "*that the same given force, when it acts under a less resistance, must necessarily produce far more powerful effects than when it acts under an increased resistance.*" And if I may be allowed this axiom, I hold myself able to prove, from Mr. Lyell's own diagram, as clearly as any mathematical truth may be demonstrated from the diagrams of Euclid, the proposition which nevertheless he somewhat unaccountably supposes himself to be opposed to, namely, that the actual convulsions of the crust of our planet neither are, nor, on the evidence which he has himself adduced, can possibly be, equal in intensity to those which prevailed in the earlier geological epochs. Instead, therefore, of comforting ourselves, as he does, with the prospect that we may expect in our own days convulsions violent as those which upheaved Mont Blanc, or "Chimborazo, giant of the western shore," we may rather repose with Leibnitz, (assuredly not a less philosophical authority,) in the persuasion, "Tandem quiescentibus causis, atque æquilibratis, consistentior emergeret rerum status." (p. 18.)

The next article in the Number is "An Introduction to Zoology, in illustration of the zoological department of the Museum of the Bristol Institution," by the Editor, Mr. Clark, with the assistance of some of that body "of which he is the organ," but by whom "the Journal has been placed under his immediate and unfettered superintendence." This article, likewise to be continued in succeeding Numbers, consists of a physiological outline of the subjects and objects of zoology, in the course of which are enunciated some philosophical views not unworthy, we think, of the existing state of the science. At the same time we must admit that we cannot agree with the authors on the subject of the gradual succession of affini-

* See Lond. and Edinb. Phil. Mag., vol. iv. p. 427—428.

ties; and we may also state our opinion that a more detailed exposition of the subject of classification would render this series of papers still more valuable to the class of readers for whom it is designed. The third article is a paper by Mr. Samuel Stutchbury, the very efficient and meritorious Curator of the Bristol Institution, read before the Philosophical and Literary Society in March 1832. It embodies, in a popular form, an outline of the history of coral reefs and islands, derived in part from various published authorities, but corroborated by the results of the author's personal observations made among the islands of the Dangerous Archipelago, and others of the Southern Pacific Ocean.

A notice of Professor Faraday's recent discoveries with regard to the laws of electro-chemical decomposition, (some time since transferred to our pages) a paper on the interference of the aërial waves propagated by the tuning-fork, by Mr. R. Addams, an article on Horticulture, and another on the Polders of Flanders, conclude the original communications, which are followed by Reviews, and scientific notices. These latter terminate the scientific division of the Number; but we may notice, among the contents of the Second Part, allotted to Literature, as intimately connected with the subject of the natural history of the human species, "An Ethnographical Memoir on the Nations of Slavonian Race," from the pen of Dr. Prichard.—Regarding the design of the West of England Journal to claim the warmest encouragement, and the specimen of the execution of that design now before us, to be at once deserving of considerable commend ation, and an earnest of future excellence, we hope that the success of this work will be such as to fulfill the wishes of its founders and supporters.

A List of two Thousand Microscopic Objects, with Remarks on the Circulation in Animals and Plants, the Method of viewing Crystals by Polarized Light, &c. &c., forming a Guide for selecting and labelling subjects of Natural History, Botany, and Mineralogy for the Microscope. By ANDREW PRITCHARD, Author of the "Natural History of Animalcules," &c. &c. London. 12mo.

Great attention has lately been paid to the improvement of the object glasses of compound microscopes, which have been brought to a high degree of perfection, and the microscope has in consequence become more than ever a popular instrument. Such researches as those of Leeuenhoeck, made with a single lens, require a patient, and even painful application of the powers of vision; these investigations of the minutiæ of nature may now be pursued with comfort and safety, some important discoveries in the physiology of animals and vegetables have already been made in pursuing them, and many more may be with confidence expected.

To those who possess microscopes this little work will be found to be an acceptable manual. The introductory observations contain some useful hints on preparing and mounting the objects; and as the price is very moderate, we recommend the purchase of two copies, one to cut up for labels for the slides, and one to be preserved for reference.

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LI. *Proceedings of Learned Societies.*

ROYAL SOCIETY.

1834. Dec. 18.—THE reading of a paper, entitled, "On the Proofs of a gradual Rising of the Land in certain parts of Sweden." By Charles Lyell, Esq., F.R.S.,—was resumed, but not concluded.

1835. January 8.—On the Proofs of a gradual Rising of the Land in certain parts of Sweden. By Charles Lyell, Esq., F.R.S.

An opinion has long been entertained that the waters of the Baltic, and even of the whole Northern Ocean, have been gradually sinking; and the purport of the present paper is, to communicate the observations which the author made during the summer of 1834, in reference to this curious question. In his way to Sweden he examined the eastern shores of the Danish islands of Moën and Seeland, but neither there, nor in Scania, could he discover any indications of a recent rising of the land; nor was there any tradition giving support to such a supposition. The first place he visited, where any elevation of land had been suspected, was Calmar; the fortress of which, built in the year 1030, appeared, on examination, to have had its foundations originally laid below the level of the sea, although they are now situated nearly two feet above the present level of the Baltic. Part of the moat on one side of the castle, which is believed to have been formerly filled with water from the sea, is now dry, and the bottom covered with green turf. At Stockholm, the author found many striking geological proofs of a change in the relative level of the sea and land, since the period when the Baltic has been inhabited by the Testacea which it now contains. A great abundance of shells of the same species were met with in strata of loam, &c., at various heights, from 30 to 90 feet above the level of the Baltic. They consist chiefly of the *Cardium edule*, the *Tellina baltica*, and the *Littorina littoreus*; together with portions of the *Mytilus edulis*, generally decomposed, but often recognisable by the violet colour which they have imparted to the whole mass. In cutting a canal from Sodertelje to lake Maelar, several buried vessels were found; some apparently of great antiquity, from the circumstance of their containing no iron, the planks being fixed together by wooden nails. In another place, an anchor was dug up; as also, in one spot, some iron nails. The remains of a square wooden house were also discovered at the bottom of an excavation made for the canal, nearly at a level with the sea, but at a depth of 64 feet from the surface of the ground. An irregular ring of stones was found on the floor of this hut, having the appearance of a rude fire-place, and within it was a heap of charcoal and charred wood. On the outside of the ring was a heap of unburnt fir wood, broken up as for fuel; the dried needles of the fir and the bark of the branches being still preserved. The whole building was enveloped in fine sand.

The author next notices several circumstances regarding buildings in Stockholm and its suburbs, from which he infers that the elevation of the land, during the last three or four centuries, has not exceeded

certain narrow limits. At Upsala he met with the usual indications of a former elevation of the sea, from the presence of littoral shells of the same species as those now found in the Baltic. Certain plants, as the *Glauca maritima* and the *Triglochin maritimus,* which naturally inhabit salt marshes bordering the sea, flourish in a meadow to the south of Upsala; a fact which corroborates the supposition that the whole of the lake Maelar and the adjoining low lands have, at no very remote period of history, been covered with salt water.

The author examined minutely certain marks which had at different times been cut artificially in perpendicular rocks, washed by the sea, in various places; particularly near Oregrund, Gefle, Löfgrund, and Edskösund; all of which concur in showing that the level of the sea, when compared with the land, has very sensibly sunk. A similar conclusion was deduced from the observations made by the author on the opposite, or western coast of Sweden, between Uddevalla and Gotenburg; and especially from the indications presented by the islands of Orust, Gulholmen, and Marstrand.

Throughout the paper a circumstantial account is given of the geological structure and physical features of those parts of the country which the author visited: and the general result of the comparison he draws of both the eastern and western coasts and their islands, with the interior, is highly favourable to the hypothesis of a gradual rise of the land; every tract having, in its turn, been first a shoal in the sea, and then, for a time, a portion of the shore. This opinion is strongly corroborated by the testimony of the inhabitants, (pilots and fishermen more especially,) of the increased extension of the land, and the apparent sinking of the sea. The rate of elevation, however, appears to be very different in different places: no trace of such a change is found in the South of Scania. In those places where its amount was ascertained with greatest accuracy, it appears to be about three feet in a century. The phænomenon in question having excited increasing interest among the philosophers of Sweden, and especially in the mind of Professor Berzelius, it is to be hoped that the means of accurate determination will be greatly multiplied.

January 15.—Second Essay on a general Method in Dynamics. By William Rowan Hamilton, Esq., Andrew's Professor of Astronomy in the University of Dublin, and Royal Astronomer of Ireland. Communicated by Captain Beaufort, R.N., F.R.S.

This essay is a sequel of the one which appeared in the last volume of the Philosophical Transactions, and which contained a general method for reducing all the most important problems of dynamics to the study of one characteristic function, or one central or radical relation. It was there remarked that many eliminations required by this method might be avoided by a general transformation, introducing the time explicitly into a part (S) of the whole characteristic function (V); and the first object of the present essay is to examine and develope the properties of this part (S), which the author designates by the term *Principal Function.* This function is applied by the author to problems of perturbation, in which he finds it dispenses with many laborious and circuitous processes, and furnishes accurate expressions,

of the disturbed configurations of a system by the rules of undisturbed motion, if only the initial components of velocities be changed in a suitable manner. Another manner of extending rigorously to disturbed, the rules of undisturbed motion, by the gradual variation of elements, in number double the number of the coordinates or other marks of position of the system, which was first invented by Lagrange, and was afterwards improved by Poisson, is considered in this second essay under a form rather more general; and the general method of calculation which has already been applied by the author to other analogous questions in optics and in dynamics, is now applied to the integration of the equations which determine these elements. This general method is founded chiefly on a combination of the principle of variations with those of partial differentials, and may furnish, when matured, a separate branch of analysis, which may be denominated the *Calculus of Principal Functions*. When applied to the integration of the equations of varying elements, it suggests the consideration of a certain *Function of Elements,* capable of being variously transformed, and which may be either rigorously determined, or at least approached to, by a corollary of the general method. With a view to illustrate these new principles, and more especially those connected with problems of perturbation, they are applied, in this essay, first, to a very simple example, suggested by the motions of projectiles, the parabolic path being treated as the undisturbed; and secondly, to the problem of determining the motions of a ternary or multiple system, with any laws of attraction or repulsion, and with one predominant mass. This latter problem, which was touched upon in the former essay, is here resumed in a new manner, by forming and integrating the differential equations of a new set of varying elements, entirely distinct in theory (though little differing in practice) from the elements conceived by Lagrange; and having this advantage, that the differentials of all the new elements for both the disturbed and disturbing masses may be expressed by the coefficients of one disturbing function.

An Account of the Eruption of Mount Etna in the year 1536, from an original cotemporary document, communicated in a letter to J. G. Children, Esq., Secretary of the Royal Society. By Sir Francis Palgrave, K.G.H., F.R.S.

Record Office of the Treasury, Chapter House,
Poets' Corner, Westminster, Jan. 14, 1835.

Amongst various shreds and fragments of the correspondence from Italy during the period that Henry VIII. was negotiating with the Italian princes, is a document of a very different nature from the rest, being an extract from a letter written by the Barone di Burgis, dated at Palermo, 10th of April 1536, and giving an account of the then recent eruption of Mount Etna.

"Die xxiij. Martii, M. D. xxxvi., nocte, Mons Ethna qui nunc Mongibellus vocatur; facto, orientem versus, ostio, emisit materiam igneam, quæ ad instar fluminis vagata est per octo miliaria in longitudine, et per unum miliare in latitudine; ejus vero altitudo erat palmarum duodecim. Eâdem nocte ignis extinctus est, et ubique

remansit nigra materies prædictæ altitudinis duodecim palmarum. Ignis totam liquefecit nivem, quæ ad instar rapidi torrentis tanto impetu defluit, ut domus, arbores, et quicquid obviam esset secum traheret.

"Sequentibus autem diebus scissa sunt alia ostia numero tredecim, quæ miro strepitu ignem evomebant ad instar bombardarum; longeque ab his per unum miliare cadebant ingentia saxa, quorum aliquot judicata sunt ponderis ultra quindecim cantanorum. Post strepitum sequebatur odor sulphureus per aliquot miliaria in locis circumvicinis. Tantus erat impetus hujus igneæ materiei, ut arbores prostraret et evelleret antequam eas tangerat, sique veterem materiem incendiorum præteritorum sæculorum, offendebat, eam denuo incendebat.

"Ex quolibet ostio profluebant amplissimi rivi, qui aliquo in loco suâ latitudine unum miliare occupabant, erantque altitudine duodecim palmarum.

"Duravit hic ignis per sex dies, et singulâ quâque nocte aspiciebatur in cacumine montis, ignis; die vero, fumus.

"Sed cognosci nequibat quem faceret effectum, quia illuc ascendere non licebat propter relictam materiem incendii."

On the Electrical Relations of Metals and Metalliferous Minerals, By R. W. Fox, Esq. Communicated in a letter to Davies Gilbert, Esq., F.R.S.

The author states that he has ascertained that the crystallized gray oxide of manganese holds a much higher place in the electro-magnetic scale than any other body with which he has compared it, when immersed in various diluted acids, and alkaline solutions: he also gives a table of the order in which other metals and minerals stand in this respect. When employed in voltaic combinations he found that on being so arranged as to act in opposition to one another, the direction of the resultant of their action, as indicated by the deflection of the magnetic needle, did not coincide with the mean of the directions of the needle when under the separate influence of each. Hence he infers that the needle is not a true index of the electricity transmitted; and that electro-magnetic action does not depend on a continuous electric current. He conceives, therefore, that the phænomena are better explained on the hypothesis of pulsations which he formerly advanced. A galvanometer of a new construction is employed by the author for weighing the deflecting force of these electrical impulses.

On the Circulation of the Blood in Insects. By John Tyrrell, Esq., A.M. Communicated by P. M. Roget, M.D., Secretary to the Royal Society.

The observations on the circulation of the blood in insects, which is a discovery of comparatively recent date, have been made almost exclusively on insects in the larva state; but the author of the present paper details a variety of observations of the same fact in insects which had arrived at their last or perfect stage of development. Among the *Myriapoda*, the circulation was traced in the *Geophilus*, and still more distinctly in the *Lithobius forficatus*. The author also detected the circulation, by the motion of globules, through the nervures of the wings of various perfect insects, namely, of some species

of the *Hemerobius, Panorpa, Phryganea*, and *Ephemera*; and particularly in the *Musca domestica*, or common house-fly. The paper is accompanied by drawings of the appearances described.

January 22.—A paper was read, entitled, "Notes on the Temperature of the Air and the Sea, &c., made in a Voyage from England to India, in the Ship Hoogly, Capt. Reeves, in the year 1833." By Alexander Burnes, Esq., F.R.S.

The observations contained in this communication are recorded in a tabular form, and show that the variations of the temperature of the sea accord very closely with those of the air, in all the latitudes which the author traversed in this voyage.

A paper was then read, entitled, "Remarks on certain Statements of Mr. Faraday, contained in the Fourth and Fifth Series of his Experimental Researches in Electricity." By John Davy, M.D., F.R.S.

Dr. Davy complains that Mr. Faraday has, in the paper referred to, made certain statements with respect to the opinions of Sir Humphry Davy relative to the conducting powers of dry nitre, and caustic potash and soda, when in fusion by heat, and also with regard to other matters connected with voltaic electricity, which are not correct; and vindicates Sir Humphry Davy from the charge of want of perspicuity in the statement of his views of these subjects.

A Note by Mr. Faraday on the preceding Remarks by Dr. Davy was then read, in which he replies to the charges there brought forward, and justifies those statements, the accuracy of which had been impugned by Dr. Davy.

January 29.—The reading of a paper was commenced, entitled, "Experimental Researches in Electricity. Ninth Series." By Michael Faraday, Esq., D.C.L., F.R.S.

February 5.—Mr. Faraday's paper, entitled, "Experimental Researches in Electricity. Ninth Series," was resumed and concluded.

In the series of experiments which are detailed in this paper, the author inquires into the causes of some remarkable phænomena relating to the action of an electric current upon itself, under certain circumstances, whereby its intensity is highly exalted, and occasionally increased to ten, twenty, or even fifty times that which it originally possessed. For the production of this effect, the principal condition is that the current traverse a considerable length of a good conductor, such as a long wire; more especially if this wire be coiled in the form of a helix; and the effect is still further augmented when this helix is coiled round a cylinder of soft iron, constituting an electro-magnet. The evidence on which these conclusions are founded is the following. If an electromotor, consisting of a single pair of zinc and copper plates, have these metals connected by a short wire dipping into cups of mercury, the electric spark consequent upon either forming or breaking the circuit is so slight as to be scarcely perceptible; but if a long wire be employed as the medium of connexion, a bright spark is obtained on breaking the contact. If the wire be coiled in a helix, the spark is still brighter; and if a core of soft iron be placed within the helix, the spark, at the moment of disjunction, is more brilliant than in any of the former cases: and the higher intensity of the cur-

rent is also manifested by the occurrence of a shock, at the same moment, to a person who grasps with wetted hands the two ends of the wire; whereas no such effect, nor even any sensible impression on the tongue, is produced by the electromotor, when a short wire is employed.

All these effects of exaltation are produced at a time when the actual current of electricity from the electromotor is greatly diminished; as the author shows by many experiments on the ignition of a fine wire, and the deflection of a galvanometer. He also proves that the effects of the spark and the shock, at the moment of disjunction of a long wire, are due to a current far more powerful than that which passes through the short wire at the same instant; or indeed than that which passes through either the long or the short wire at any other instant of time than when the disjunction takes place.

That this extraordinary effect is not due to any species of inertia, is shown by the fact, that the same wire will produce it in a greater or less degree, under circumstances incapable of influencing any effect depending on inertia: thus, if 100 feet of wire, when extended, produce a certain effect, a greater effect will be produced by coiling the same wire into a helix, and a still more powerful one by employing it as the helix of an electro-magnet.

The author ultimately refers these phænomena to an inductive action of the current, analogous, or perhaps identical, with that described in the First Series of these Experimental Researches: for he found that when a second wire was placed parallel to the long conducting wire, the ends of this second wire being connected together so that a current of electricity could circulate round it, then the spark and shock did not take place at the first wire at the moment of disjunction, but a current was induced at the second wire, according to the law originally described in the First Series. The moment the current in the second wire was interrupted, the spark and shock appeared at the first. These and many other experiments were adduced to prove that these effects, namely, the shock and the spark, result from an inductive action of the original current, producing, at the moment it is stopped, a current, in the same direction as itself, in the same wire which serves to convey the original current.

The author, lastly, considers the reverse effect produced upon making contact; and concludes his paper by some general views of the consequences resulting from this inductive action in various cases of electric discharge; pointing out the important influence it must have in magneto-electrical machines of the ordinary construction.

The reading of a paper was then commenced, entitled, "Geometrical Researches concerning Terrestrial Magnetism." By Thomas Stephens Davies, Esq., F.R.S., &c.

February 12.—Mr. Davies's paper, entitled "Geometrical Researches concerning Terrestrial Magnetism," was resumed and concluded.

The object of this paper is to exhibit methods of conducting the mathematical inquiries which are applicable to the magnetism of the earth, by the aid of the coordinate geometry of three dimensions.

When a point on the surface of the earth is given by means of its geographical coordinates, we can also refer it to any rectilinear coordinates that may be found convenient, and the transformations of the expressions can be made by known and familiar methods. Also, since at a given point the needle is deflected a measured quantity from the meridian plane, estimated on a tangent plane to the earth at the given point, and is also depressed another measured quantity below the same plane at that given point, its position is fixed by means of these measures. It will hence become capable of reference also to the same rectilinear coordinates as those into which the geographical coordinates were transformed. The equation of the line, into which the dipping-needle disposes itself, becomes, therefore, capable of expression in terms of the measured quantities above referred to; viz., the latitude, longitude, dip, and variation. The method of obtaining the constants which enter into the "equations of the needle" as referred to the equator, a given meridian, and the meridian at right angles to it, are then detailed at length by the author; and these equations are calculated for six different places: Port Bowen, Boat Island, Chamisso Island, Valparaiso, Paris, and Paramatta.

With a view to bring the hypothesis of the duality of the centres of magnetic force to a test, the author proceeds to reason, that as a free needle subjected to the action of only two poles, will always dispose itself in the plane which passes through those poles and the centre of motion of the needle, the needle prolonged will always intersect the magnetic axis, or line which passes through the two poles. But when four straight lines are given in space, a fifth line (or rather two lines) can be so drawn as to intersect them all. If, therefore, we have the equations of four dipping-needles calculated from correct observations, we ought to be able to assign the equations of the two lines which rest upon them; one or other of which, in such case, will be the magnetic axis itself. This line ought to intersect every other needle; and hence the constants in its equations and the constants in the equations of any fifth needle ought to fulfill the algebraical test of intersection. The author has calculated the equations of the magnetic axis for the needles at Chamisso, Valparaiso, Paramatta, and Port Bowen, and made a comparison of it with the Paris needle. Instead of intersecting, the least distance between the said axis and needle is more than one 6th of the terrestrial radius; and hence, could the observations themselves be depended on, as being free from instrumental error and from local disturbances, the question of the duality of the centres of force would be at once settled in the negative; but, as the opinions of those philosophers who are best acquainted with the dipping-needle are decidedly that the dipping-needle is not yet in such a condition as to induce implicit confidence in its indications, and as, moreover, the influence of geological and meteorological sources of disturbance are yet so far unappreciated as to enable us to correct the observations for them, the author hesitates to draw any positive conclusion from the results he has obtained. However, the results thus obtained, being the direct and legitimate deductive consequences of the observations, it is of course impossible by any other course of investigations which proceeds

from the same data, to draw a conclusion more to be depended on than this. The process he considers to be mathematically correct, as well as complete, and practicable; the question, as far as this test is concerned, must remain open till satisfactory data can be obtained: and he proposes at the earliest period to resume the numerical discussion of such observations as he may be able to procure.

Mr. Davies remarks, that from the great labour of the calculations, he has been led to attempt a more brief method of examination by means of carefully executed geometrical constructions; employing for that purpose the descriptive geometry, which has the advantage of bringing all the work to depend on the intersection of the hyperbola and straight line, situated upon the same plane. The resulting magnetic axes of the few cases he has constructed, though very far from coinciding, are yet positive in the same general region of the figure; and therefore the probability that their want of coincidence arises from erroneous and uncorrected observation is increased, and the importance of a more extended and careful series of observations considerably augmented.

For the purpose of examining the general character of the magnetical phænomena which ought to result from the hypothesis of the duality of the poles, Mr. Davies proceeds to investigate the formulæ which express those phænomena. These are, the magnetic equator,—the points at which the needle should become vertical,—the lines of equal dip,—the Halleyan lines, or lines of equal variation,—the isodynamic lines of Hansteen,—and the points at which the magnetic intensity, compared with the points immediately contiguous in all directions, is a maximum, or in other words, where the isodynamic lines are reduced to points. The first two of these only, are treated in the present paper; the remaining ones will be the subject of a future memoir shortly to be submitted to the Society.

The mathematical processes themselves scarcely admit of verbal description; but the results of the investigation are briefly these.

When the centres of force are situated within the sphere, there will be one only, or some even number of continuous lines on the surface of the earth, at any point of which the needle will be horizontal, according as the poles be of equal or unequal intensities. Whether the magnetic equator be determined with sufficient accuracy to assure us that there is but one such line, is a matter of considerable doubt; but if it should be admitted that it is, it offers a strong confirmation of the strict analogy between the terrestrial and all other magnets with two poles, and thence an increasing confidence in all the other analogies conceived to exist between them.

The points at which the needle is vertical are given by means of two equations, one of the fifth and the other of the second degree, and hence altogether there are ten such points theoretically possible. How many of these may be simultaneously real the equations do not, in their literal form, seem capable of determining; but at all events they will, in all cases, be an even number, either 0, 2, 4, 6, 8, or 10. One having been determined, one other at least must exist in the actual circumstances of the terrestrial two-poled magnet. How many so

ever such simultaneous points there may be, they must all lie in the same plane; and hence, if the second point which must exist could be determined, then the great circle in the plane of which the axis of the magnet itself is situated would be determined; and thus another test would be afforded of the truth or error of the hypothesis itself. Mr. Davies suggests that as this plane will be symmetrical with respect to the phænomena taking place on each side of it, its position might be tentatively assigned from a series of observations of those phænomena, especially of the dip and intensity; the variation being for obvious geometrical reasons excluded.

Though the resulting formula does not in its literal form appear to be capable of decomposition into factors, yet from some considerations, chiefly analogical, Mr. Davies is led to hazard the conjecture that it is capable of such decomposition; but as this is uncertain, he builds no consequences upon it, but leaves those consequences which would flow from it, open till it shall be discovered whether they would be justified by the conjecture itself being proved to be correct.

A paper was also read, entitled, "On certain Peculiarities in the double Refraction, and Absorption of Light, exhibited in the Oxalate of Chromium and Potash." By Sir David Brewster, K.H., L.L.D., F.R.S.

The crystals of the oxalate of chromium and potash are, generally speaking, opake; for at thicknesses not much greater than the 25th of an inch, they are absolutely impervious to the sun's rays, and their colour, seen by reflected light, is nearly black; but when powdered, they are green; and the colour of the smaller crystals, viewed either by reflected or by transmitted daylight, is blue. One of the most remarkable of the properties of this salt is the difference of colour in the two images formed by double refraction. At a certain small thickness, the least refracted image is bright blue, and the most refracted image bright green. The blue is found by analysis with the prism to contain an admixture of green, and the green an admixture of red; and by candlelight this red predominating over the green, gives the crystal a pink hue. At greater thicknesses the blue becomes purer and fainter, and the green passes into red; and at a certain thickness the least refracted blue image disappears altogether, and the most refracted image is alone seen. At still greater thicknesses this image also disappears, and absolute opacity ensues. When the crystal is exposed to polarized light, with its axis in the plane of polarization, the transmitted light is green; but when the axis is perpendicular to that plane, the transmitted light is blue. A solution of the salt exhibits the same general action upon light as the solid, with the exception of double refraction. This salt has also the peculiar property of exciting a specific action upon a definite red ray, situated near the extremity of the red portion of the spectrum.*

ASTRONOMICAL SOCIETY.

1834. *Dec.* 12.—The President read a letter from His Royal Highness the Duke of Sussex, acknowledging the vote of thanks passed

* See our Number for January, p. 134.

at the last meeting, and expressing interest in the welfare of the Society.

The following communications were read :

I. Some particulars of the Life of Dr. Halley. Communicated by Professor Rigaud, through Mr. Baily.

The manuscript memoir, containing the particulars here alluded to, was found in the Bodleian Library, at Oxford ; it is a small quarto, and consists of twenty leaves. The author is not known ; but it appears that he was of Cambridge University, was acquainted with Halley and Dr. Sykes the orientalist, and wrote before Halley's manuscript observations were out of the hands of his executors. As some of the circumstances therein mentioned are not generally known, the memoir was read as a sort of appendix to the paper communicated at the last meeting of the Society. It appears that it was Dr. Halley's intention, very early in life, to form a new catalogue of stars from actual observation ; but finding that this ground was already occupied by Hevelius and Flamsteed, he directed his attention to the southern hemisphere ; and under the sanction of His Majesty King Charles II., he was despatched to the island of St. Helena, furnished with the following instruments : An excellent brass sextant, of $5\frac{1}{2}$ feet radius, well fitted up with telescope-sights, indented semicircles of the same metal, and screws for the ready bringing it into any plane ; a quadrant of about 2 feet radius, which he intended chiefly for observations whereby to adjust his clock ; a telescope of 24 feet ; some lesser ones ; two micrometers ; and a good pendulum-clock. He immediately, on his arrival at St. Helena, set himself to work ; and from his observations deduced the catalogue of southern stars that was published in 1679. After some other journeys on the Continent, he returned to England ; and in 1682 married Mrs. Mary Tooke. Intending now to settle some time at home, he resolved to pursue his astronomical observations, and therefore fixed the sextant which he had at St. Helena in a small observatory which he had fitted up at Islington, where he carried on a regular course of observations (of the moon principally) from November 7, 1682, to June 16, 1684, the account of which is published at the end of Street's *Astronomia Carolina.* When the great recoinage of clipt money was made by King William III., five mints were erected, for that purpose, out of London : and Dr. Halley was appointed comptroller of the mint at Chester. In the year 1698, he was directed by His Majesty to proceed on a voyage for determining the law of the variation of the magnetic needle : and in the year 1701 he was instructed to make observations on the tides in the English Channel, and to take the bearings of the different headlands on the coast. At the anniversary meeting of the Royal Society in November 1713, he was chosen secretary in the room of Sir Hans Sloane, who resigned that office : and on the decease of Mr. Flamsteed, at the close of the year 1719, he was recommended by the Earl of Macclesfield, then lord chancellor, by the Earl of Sunderland, then secretary of state, and by others, as the fittest person to fill the office of Astronomer Royal ; to which situation he was appointed on Feb. 9, 1719-20, and which he held till the day of his death.

Among the circumstances which are here recorded, and which are not very usually mentioned, if indeed they are known at all, are—that of Halley's appointment to the mint above mentioned—his having drawn up a synopsis of Newton's system for the use of James II., at the desire of the latter—that his first voyage, by express direction, was meant to be one of discovery in the Southern Ocean—and that his acquaintance with Newton began about 1684.

II. Translation of a paper by Dr. Olbers in the *Astronomische Nachrichten*, No. 268, on the approaching return of Halley's comet. Translated and communicated by Mr. Galloway. This communication was given entire in our last Number, p. 45.

III. Observed Transits of the Moon and Moon-culminating Stars over the Meridian of Edinburgh Observatory, in October and November, 1834, by Mr. Henderson. They are given in the Monthly Notices.

IV. Transits of the Moon with Moon-culminating Stars, observed at Cambridge Observatory in the month of November, 1834. Also given in the Monthly Notices.

ZOOLOGICAL SOCIETY.

1834. *Dec.* 9.—The reading was concluded of a Paper entitled "Notes on the Natural History and Habits of the *Ornithorhynchus paradoxus*, Blum.," by Mr. George Bennett, Corr. Memb. Z.S.; in which the author gives a detailed account of his inquiries and researches on the subject in question, made in the Colony of New South Wales, and in the interior of New Holland, at the end of 1832 and commencement of 1833. He commences by a description of the external character of the animal, as observed by him in the living and recent state; from which it appears that the greater or less degree of nakedness of the under surface of the tail is dependent on age, and is probably a result of the mode in which that organ trails upon the ground; that the colour of the upper mandible above, in an animal recently taken out of the water, is of a dull dirty greyish black covered with innumerable minute dots, and the under surface of the lower white in the younger specimens, and mottled in the more aged, while the inner surface of both is of a pale pink or flesh colour; that the eyes are brilliant, and light brown; and that the external orifices of the ears, which are with difficulty detected in dead specimens, are easily discoverable in the living, the animal exercising the faculty of opening and closing them at will. When recent, and especially when wet, the *Ornithorhynchus* has a peculiar fishy smell, proceeding probably from an oily secretion. It is used as food by the Natives, by whom it is called, at Bathurst and Goulburn Plains, and in the Yas, Murrumbidgee and Tumat countries, by the names of *Mallangong* or *Tambreet*. Mr. G. Bennett is inclined to regard the two species usually described in modern books as not differing sufficiently from each other to justify their separation, and he therefore retains the name of *Orn. paradoxus* given to the animal by Professor Blumenbach, the universal adoption of which renders it inexpedient in this instance to recur to the older name

of *Platypus* imposed on it by Shaw. He remarks on the distortions to which the exceedingly loose integuments are liable in the hands of stuffers unacquainted with the characteristic features of the animal, and gives the general result of his measurements, in the recent state, of fifteen specimens shot and captured alive, as averaging in the males from 1 foot 7 to 1 foot 8 inches, and in the females from 1 foot 6 to 1 foot 7 inches, in total length. One male specimen, shot near the Murrumbidgee River, measured 1 foot 11¼ inches; and a female, shot in the afternoon of the same day in the same part of the river, measured only 1 foot 4 inches. In these specimens the relative proportions of the beak and tail were subject to considerable variation.

Mr. G. Bennett's observations were commenced on the 4th of October 1832, at Mundoona in the Murray County, on a part of the Yas River running through the estate of Mr. James Rose. The *Water-Moles* (as these animals are called by the Colonists,) chiefly frequent the open and tranquil parts of the stream, covered with aquatic plants, where the steep and shaded banks afford excellent situations for the excavation of their burrows. Such expanses of water are by the Colonists called "ponds." The animals may be readily recognised by their dark bodies just seen level with the surface, above which the head is slightly raised, and by the circles made in the water around them by their paddling action. On the slightest alarm they instantly disappear; and indeed they seldom remain longer on the surface than one or two minutes, but dive head foremost with an audible splash, reappearing, if not alarmed, a short distance from the spot at which they dived. Their action is so rapid, and their sense of danger so lively, that the mere act of levelling the gun is sufficient to cause their instant disappearance; and it is consequently only by watching them when diving, and levelling the piece in a direction towards the spot at which they seem likely to reappear, that a fair shot at them can be obtained. A near shot is absolutely requisite; and when wounded they usually sink immediately, but quickly reappear on the surface.

A male specimen was shot, and brought out by the dog, on the following morning. In a few minutes it revived, and ran along the ground, instinctively endeavouring to regain the water, but did not survive more than twenty-five minutes. On this individual Mr. G. Bennett made various experiments, with the view of ascertaining the truth of the reports so extensively circulated of the injurious effects resulting from wounds inflicted by the spur. In no way, however, could he induce the animal to make use of its spurs as weapons of offence; although in its struggles to escape, his hands were slightly scratched by the hind claws, and even, in consequence of the position in which he held it, by the spur also. The result of several subsequent repetitions of the experiment with animals not in a wounded state was the same. The natives, too, never seem fearful of handling the male *Ornithorhynchus* alive.

On the evening of the same day a female was shot, which died almost immediately on being taken out of the water. In this speci-

men the mammary glands were scarcely observable on dissection; but the left *uterus* was found to contain three loose *ova* of the size of swan-shot. The right *uterus* was less enlarged, exhibited less vascularity, and contained no *ova*. Preparations of the generative organs of this individual, and of two other impregnated females which were subsequently obtained, were forwarded by the author to Mr. Owen, by whom they have been particularly described in the 'Philosophical Transactions' for 1834, p. 555*.

The next day three other specimens were shot: a male and two females. In the former the *testes* were found not to be larger than very small peas, and the same fact was observed in a specimen afterwards shot in the Murrumbidgee; whereas in that first obtained, they were nearly of the size of pigeons' eggs. For this difference at the same season it seems difficult to account. The left *uterus* of one of the females was found to contain two *ova*, and that of the other a single *ovum*, of the size of buck-shot. As before, no *ova* were found in the right *uterus*.

On the morning of the 7th of October, Mr. G. Bennett proceeded, in company with a native, to the banks of the river to see the burrow of an *Ornithorhynchus*, from which the natives had taken the young during the previous summer. The burrow was situated on a steep part of the bank; and its entrance, concealed among the long grass and other plants, was distant rather more than a foot from the water's edge. Its whole extent was not laid open, the natives contenting themselves with digging down upon it at stated distances, their operations being guided by the introduction into the burrow of a stick which indicated its direction. It took a serpentine course, and measured about twenty feet in length: the termination was broader than any other part, nearly oval in form, and strewed with dry river-weeds, &c. From this nest the native stated that he had taken in the previous season (December) three young ones, about six or eight inches in length, and covered with hair. In addition to the entrance above spoken of, the burrows have usually a second below the surface of the water, communicating with the interior just within the upper aperture. After exhibiting this burrow, the native proceeded to explain the means employed in tracking the *Mallangongs*. He pointed out on the moist clay of the banks foot-marks leading to a burrow, from the bottom of which, on inserting his arm, he drew forth some lumps of clay, which bore evident marks of the animal's recent passage. He declared, however, that the inhabitant was absent, and Mr. G. Bennett was induced, by this information, to abstain from further investigation. A female specimen, shot in the evening of the same day, was found to have two *ova*, about the size of or rather smaller than buck-shot, in the left *uterus*; and in this, as in all the other female specimens, much difficulty was experienced in finding the mammary glands. The contents of the cheek-pouches and stomachs always consisted of river insects, very small shell-fish, &c., comminuted and mingled

* An abstract of Mr. Owen's paper was given in our number for January, pp. 60, 61.

with mud or gravel, which latter, Mr. G. Bennett suggests, may be required to aid digestion. River-weeds were never observed to form part of the food; but Mr. George MacLeay informed the author that in a situation in which water-insects were very scarce he had shot *Ornithorhynchi* with river-weeds in their pouches.

Similar excursions were made on the 8th and 9th of October; and on the latter day one of the burrows was explored. The entrance of this burrow was situated on a moderately steep bank, abounding with long wiry grass and shrubs, at the distance of about five feet from the water's edge: its course lay in a serpentine direction up the bank, approaching nearer to the surface of the earth towards its termination. At this part it was expanded to form a chamber sufficiently capacious for the reception of the animal and her young, and measured one foot in length by six inches in breadth. Its whole length, from the entrance to the termination, was twenty feet; narrowing as it receded from the entrance, where it measured one foot three inches in depth, and one foot one inch in breadth, and in the intermediate part becoming scarcely larger than the usual breadth of the animal when uncontracted.

From this burrow a living female was taken, and placed in a cask, with grass, mud, water, &c.; and in this situation it soon became tranquil, and apparently reconciled to its confinement. Hoping that he had now obtained the means, should his captive prove to have been impregnated, of determining the character of the excluded product, Mr. G. Bennett set out on his return for Sidney, on the 13th of October, carrying the living *Ornithorhynchus* with him in a small box, covered with battens, between which only very narrow intervals were left.

The next morning, tying a long cord to its leg, he roused it and placed it on the bank of the river, in order to indulge it with a bathe; and a similar indulgence was granted to it on the second day of its journey. On these occasions it soon found its way into the water, and travelled up the stream, apparently delighting in those places which abounded most with aquatic weeds. When diving in deep and clear water, its motions were distinctly seen: it sank speedily to the bottom, swam there for a short distance, and then rose again to the surface. It appeared, however, to prefer keeping close to the bank, occasionally thrusting its beak into the mud, from whence it evidently procured food, as on raising the head, after withdrawing the beak, the mandibles were seen in lateral motion, as is usual when the animal masticates. The motions of the mandibles were similar to those of a duck under the same circumstances. After feeding, it would lie sometimes on the grassy bank, and at others partly in and partly out of the water, combing and cleaning its coat with the claws of the hind feet. This process occupied a considerable time, and greatly improved its sleek and glossy appearance. After its second excursion it was replaced in the box, which was not opened again until the following morning, when it was found to have made its escape.

Although the summer season was now far advanced, Mr. G.

Bennett determined to return to the interior and renew his investigations. On the 15th of November he again arrived at Mundoona, where he found that the river had fallen greatly, and sought in vain for the *Water-Moles* in the spots in which they had a few weeks before been so abundantly seen. Some burrows were also examined, but without success. On the 21st he proceeded to Gadarigby, on the Murrumbidgee, where his exertions were more successful, several specimens being obtained; but the only female shot was young and unimpregnated. On the 27th he returned to Mundoona, where a female had been shot the previous day, the uterine organs of which afforded evidence that the young had been just produced. The abdominal glands were large, but no milk could be expressed from them; the fur still covered the portion of integument on which its ducts terminated; and there was no appearance of projecting nipple. No such projection was observed in any of the specimens in which the secretion of milk was demonstrable. Two other females were procured at the same place; but both proved to be unimpregnated.

On the 8th of December Mr. G. Bennett quitted Mundoona for the banks of the Murrumbidgee, and near Jugiong, on the latter river, had an opportunity of inspecting the burrow of an *Ornithorhynchus*, containing three young ones, which appeared to have not long previously been brought forth. They were only thinly covered with hair and measured in length about 1⅞ inch. No fragments of shells were observable in the burrow, nor anything that could lead to the supposition of the young having been excluded while yet in the egg. A want of spirit in which to preserve these interesting specimens unfortunately prevented their conveyance to Sidney.

On the 28th of December the author visited a part of the Wollondilly River, in the neighbourhood of Goulburn Plains, called by the Natives Koroa, in order to explore the burrow of an *Ornithorhynchus* which had there been discovered. The termination of this burrow was thirty-five feet from the entrance; and Mr. G. Bennett states that burrows have been observed of even fifty feet in length. It was found to contain two young specimens, of the dimensions of 10 inches from the beak to the extremity of the tail. The nest consisted of dry river-weeds, the *epidermis* of reeds, and small dry fibrous roots, strewed over the floor of the terminal cavity. An old female was captured soon after on the banks of the river, in a ragged and wretched condition, which was conjectured to be the mother. But little milk could be pressed from her abdominal glands, as might have been expected in the parent of such well-grown young ones. She died at Mittagong, on the 1st of January, but the young ones survived until some time after their arrival in Sidney.

Mr. G. Bennett proceeds to describe in detail their habits in a state of captivity. Their various attitudes, when in a state of repose, are strikingly curious, and were illustrated by the exhibition of sketches made from the life. The young were allowed to run about the room; but the old one was so restless, and damaged the walls of the room so much by her attempts at burrowing, that it was found necessary to confine her to the box. During the day she would

remain quiet, huddled up with her young ones; but at night she became very restless, and eager to escape. The little ones were as frolicsome as puppies, and apparently as fond of play: and many of their actions were not a little ludicrous. During the day they seemed to prefer a dark corner for repose, and generally resorted to the spot to which they had been accustomed, although they would change it on a sudden apparently from mere caprice. They did not appear to like deep water, but enjoyed exceedingly a bathe in shallow water, with a turf of grass placed in one corner of the pan: they seldom remained longer than ten or fifteen minutes in the water at one time. Though apparently nocturnal, or at least preferring the cool and dusky evening to the glare and heat of noon, their movements in this respect were so irregular as to furnish no grounds for a definite conclusion. They slept much, and it frequently happened that one slept while the other was running about, and this occurred at almost all periods of the day. They climbed with great readiness to the summit of a bookcase, placing their backs against the wall and their feet against the bookcase; and thus, by means of their strong cutaneous muscles and of their claws, mounting with much expedition to the top. Their food consisted of bread soaked in water, chopped egg, and meat minced very small; and they did not seem to prefer milk to water. One of the young ones died on the 29th of January 1833, and the other on the 2nd of February, having been kept alive in captivity for nearly five weeks.

GEOLOGICAL SOCIETY.

1835. January 7th.—A letter from Dr. Bostock, F.G.S., addressed to George Bellas Greenough, Esq. P.G.S., containing an account of the analysis of a mineral water from the Island of St. Paul, in lat. 38° 45′ S. and long. 77° 53′ E., was first read.

The island of St. Paul is stated, on the authority of Capt. Ford and Mr. Houslip, to be of volcanic origin, very rugged in its outline, and to have the form of a bowl, 10 or 12 miles in circumference, into which the sea flows by a narrow opening, capable of admitting a boat. The surface of the island is, in many places, covered with pumice, and at night flames were observed to issue from various crevices in the rocks. With the exception of the island of Amsterdam, about 40 miles to the north of it, St. Paul's is at a great distance from any land.

In the hole from which the water was taken the thermometer stood at 212°.

Dr. Bostock then explains the manner in which he conducted the examination, and gives the following as the earthy constituents of 100 grains of the water:

Muriate of soda	2·3	grains.
Sulphate of soda	·053	
Muriate of lime	·340	
Muriate of magnesia	·059	
Loss	·038	
	2·790	

He afterwards compares these results with those obtained by Dr. Marcet from water procured from the middle of the South Atlantic; and from the great difference in the saline contents, infers that the water of the island of St. Paul is not merely the water of the neighbouring ocean in a state of dilution, or altered simply by mechanical filtration.

A paper "On the chalk and flint of Yorkshire, compared with the chalk and flint of the southern counties of England," by James Mitchell, LL.D., F.G.S., was then read.

The chalk of Yorkshire, Dr. Mitchell states, is distinguished from that of the southern counties by its great hardness, by its being occasionally of a red colour*, by its being more distinctly stratified, and by its containing veins of calcareous spar. He says, that it is also distinguished by the upper part being always destitute of flints, while in the southern counties the absence of flints in the upper part is an exception.

The flints of Yorkshire are shown to differ from those of the southern counties by their being almost invariably of a tabular form, constituting regular and well-defined continuous layers; by being tougher, and breaking into short small fragments, unfitted for the manufacture of gun flints; by the colour being always greyish or whitish throughout the whole thickness; the crust not being of a different character from the body of the flint. Nodules of iron pyrites are stated to be common in the Yorkshire chalk, but in that of the South of England to be confined to the lower chalk without flints.

In conclusion the author points out the following resemblance between the Yorkshire chalk and that of the N.E. of Ireland, namely, the great hardness of both, and the common occurrence in both of iron pyrites and veins of calcareous spar.

A letter was next read from Woodbine Parish, Esq., addressed to George Bellas Greenough, Esq., P.G.S., accompanying a suite of specimens from the neighbourhood of Bognor.

The collection, referred to in this letter, contained a series of all the fossils hitherto described as occurring in the Bognor Rock, and a suite of specimens of *Choanites Kœnigii* obtained from the rolled shingle on the beach. Mr. Parish also points out for the first time the existence of chalk on the shore opposite Felpham, between high and low water mark. He states that it may be traced for upwards of a mile in the direction of Middleton; that at the point where it first appears, it is hard and thickly interspersed with flints, but that further on it becomes soft and the flints are less numerous. Mr. Parish procured from it many of the characteristic chalk fossils. He states also that near Middleton, chalk marl has been long dug at low water.

A notice on the want of perpendicularity of the standing pillars of the Temple of Jupiter Serapis near Naples, by Capt. Basil Hall, R.N., F.G.S., was afterwards read.

Capt. Hall observes that the three pillars of the Temple of Serapis

* See Phil. Mag. and Annals, N.S., vol. ix. p. 434.

now standing, each of which is formed of a single piece of stone, are not strictly perpendicular, but all slope towards the south-west, that is, towards the sea, and from the temple where the statue of Jupiter is supposed to have stood. It is well known the columns of ancient Greek temples, the Parthenon for instance, have an inclination inwards. The slope of the columns in that of Serapis is not great, but very decided, and was established by measurement and by observations on the angle formed by the reflection of the columns in the water, which covers the pavement of the temple at high tides. The floor of the temple is also slightly inclined, for Capt. Hall observed, that on the recession of the tide, the northern side was left dry, when the water was still some inches deep on the southern side.

January 21.—A paper was first read "On an outlying basin of Lias on the borders of Salop and Cheshire, with a short account of the lower Lias between Gloucester and Worcester," by Roderick Impey Murchison, Esq., V.P.G.S.

Having heard from Mr. Dod of Cloverly that frequent trials for coal had been made in a part of North Salop situated between the Hawkstone Hills and the towns of Whitchurch and Market Drayton, the author visited that district during the autumn of last year. He found that the strata, supposed to be coal shale, belong to the lias, and that they range over a considerable area resting upon red marl and new red sandstone. With the assistance of the Rev. T. Egerton, F.G.S., he has ascertained that this lias occupies an elliptical basin, the length of which from S. W. to N. E. is 10 miles, and the breadth about 4 to 6, the surrounding strata dipping inwards at slight angles. The western boundary only is indeterminable, being concealed by gravel and turf bog. The formation is divisible into marlstone and lower lias. The first is clearly exposed in the hill of Prees, and contains the fossils which characterize it in Gloucestershire and Worcestershire, viz., *Avicula inæquivalvis*, *Gryphæa gigantea*, and *Pecten æquivalvis*, with an Ammonite, in great abundance, resembling *A. geometricus* of Phillips.

The lower lias crops out at various points along the exterior of the ellipse, particularly between Moreton Mill and Burley Dam; near the last of which places it is, in parts, bituminous and slaty, like the Kimmeridge coal. Near Cloverly and Adderley the lias shale has been penetrated by shafts in search of coal to the depth of 300 feet, and numerous fossils have been extracted, among which are, *Ammonites Bucklandi*, *A. Conybeari*, *A. planicosta*, *A. planorbis*, *A. communis?*, *A.* ——, published in Zeiten's Wirtemberg fossils, and four species of undescribed Ammonites; *Astarte elegans*, *Belemnites subclavatus* (Voltz, found in the lias of Boll), Cidaris, *Gryphæa incurva*, *G. MacCullochii*, *Modiola minima*; Pecten and Pullastra (two unpublished species, both occurring at Brora); *Plagiostoma pectinoides*, first published from Brora; *P. giganteum*, *Pentacrinites scalaris*, Goldfuss; Rostellaria? Spirifer, Tellina, Unio, Turritella, and unpublished Serpulæ?

Among these fossils some are universally characteristic of the formation, others were first observed in the lias of the distant di-

stricts of Brora in Scotland, and of Boll and Banz in Germany. Some of the sinkings produced small pieces of jet or lignite like that of Whitby; others nearer the escarpment went through the lias, and reached brine springs in the subjacent red marl.

Having proved that this basin of lias reposes upon the new red sandstone, the author adverts to the almost unfathomable thickness of strata by which it must be separated from the coal-measures. Three fourths of this tract of lias are covered with thick accumulations of gravel, sand and boulders, the nature and origin of which will be pointed out on a subsequent occasion. With this sketch is connected an account of a new base line of the lower lias which the author has laid down upon the Ordnance map between Gloucester and Worcester. It crosses to the right bank of the Severn in the neighbourhood of Tewkesbury, by Forthampton and Bushley, the lias occupying Longden Heath as an outlier. The lowest strata of the formation are described as graduating into inferior green marls and white sandstone of the new red sandstone at Combe Hill, Bushley, Longden, Ripple, and Boughton Hill; the characteristic strata a little above the line of junction being thin, flag-like beds of blue limestone and shale, characterized by *Modiola Hillana*, Ostreæ, Spines of Echini, *Gryphæa gigantea*, *&c. &c.* This clear escarpment of the lower lias is of value, because the same strata are not well exposed in the coast sections at Whitby and Lyme.

A paper was afterwards read entitled, "A general view of the new red sandstone series, in the counties of Salop, Stafford, Worcester, and Gloucester." By Roderick Impey Murchison, Esq., V.P.G.S.

Viewing the new red sandstone which occurs in parts of Salop, Stafford, and Worcester, in the extended sense first applied to it by Mr. Conybeare*, as including all the deposits between the lias and the coal-measures, the author endeavours to divide the group into distinct subformations; an attempt which had not been made, the whole having been hitherto laid down upon maps as one formation. Following, as far as the structure of the country would allow, the divisions established by Professor Sedgwick for the N. E. of England, it is shown that the series is divisible into the undermentioned subformations:

	Foreign Equivalents.
1. Red and green marls..........	*Keuper.*
2. Sandstone and conglomerates..	*Bunter sandstein, Gres bigarré.*
3. Calcareous conglomerates....	*Zechstein, &c. &c.*
4. Lower red sandstone	*Rothe todte liegende.*

I. "*Red and Green Marls.*"—These are best developed in Gloucestershire and Worcestershire, where they contain a subordinate white sandstone, undistinguishable from certain varieties of the Keuper-sandstone of the Germans. In the marls are situated most of the brine springs, both in these counties and in Salop and Cheshire, though some of them rise out of the inferior sandstone. But gypsum is not so abundantly developed as in the south-western districts

* Outlines Geol. England and Wales, p. 278.

of England, occurring rarely, and in thin stripes. There is no trace of the "muschelkalk" beneath these marls, and they uniformly graduate downwards into sandstone.

II. "*Red Sandstone and Conglomerates.*"—The country north of Shrewsbury affords the largest development of thick-bedded sandstones, of grey and reddish colours, in the hills of Hawkstone, Wern, Grinshill, Nesscliff, &c. Ores of copper and manganese, with sulphate of strontian, and chalcedony are of partial occurrence. This group extends into Staffordshire and the east of Shropshire, where it contains many bands of quartzose conglomerates, the disintegration of which gives a wild and sterile character to large tracts. In other parts, particularly north and south of Kidderminster, where the pure sandy beds prevail, are large districts of rye land, which exhibit an agricultural character quite distinct from that of any of the groups either above or below. In the southern parts of Worcestershire these red sandstones and conglomerates are concealed by a thick covering of gravel, and in Gloucester they are reduced to a very narrow band. The division into thick beds, false lamination, and want of cohesion, are the characters of this group.

III. "*Calcareous Conglomerates.*"—In North Worcester and Salop calcareous conglomerates, forming natural escarpments and dipping beneath the above sandstones, are supposed to occupy the place of the dolomitic conglomerate of the south-west, or magnesian limestone of the north-east, of England. They are largely burnt for lime to the east of the Lickey and Clent Hills, where they are of irregular thicknesses. These strata are repeated at Enville, the Bowells, and at Coton, &c., between Kidderminster and Bridgnorth.

The chief imbedded fragments are of limestone, which at Coton and the Bowells being sometimes oolitic, are supposed to have been derived from Orelton and the Clee Hills. Fragments of old red sandstone, quartz, and coal grits with impressions of plants, occur in the impure beds which pass into calcareous grits. This calcareous conglomerate can only be partially detected in the red sandstone of Apley, Nedge Hill and Lilleshall terraces, which form the eastern boundary of the coal-field of Coalbrook-dale; and similar slender bands, around the Dudley coal-field, may possibly be composed of the same conglomerate. In the west of Shropshire these strata swell out into a distinct ridge of about two miles in length, extending from Cardeston to Alberbury, where they have been mentioned in previous abstracts by Professor Sedgwick* and by the author, and where they put on many of the characters of the dolomitic conglomerate and contain nests lined with crystals of dolomite.

IV. "*Lower New Red Sandstone.*"—In Worcester and Salop the natural escarpment above alluded to exhibits sandstone and argillaceous marls, sometimes of great thickness, underlying the calcareous conglomerate. As these are seen in several places to pass down conformably into the coal-measures, the author identifies them with the

* Geol. Proceedings, vol. i. p. 345.

lower new red of the North of England, which Professor Sedgwick has shown to be the equivalent of the rothe todte liegende of German geologists. Such relations are seen in the eastern parts of the Lickey Hills, on the southern and eastern face of the coal-field of Coalbrook-dale, and in parts of the Shrewsbury coal-field.

At Cantern bank near Bridgnorth and along a part of the bed of the Severn, these strata dip away conformably from the underlying coal-measures. Similar relations are seen at Wellbatch near Shrewsbury, and still better at Coedway near Alberbury, where the red sandstones and shales graduate upwards into the dolomitic conglomerate, and downwards into coal-bearing strata. On the whole this subformation, containing sandstone, shale, and grits, has in some parts much the external appearance of the old red sandstone, and in others of the coal-measures, and impressions of plants have been found in it near Lilleshall and at Wellbatch. As coal has been extracted in many parts of the North of England from beneath sandstone of this age, the author speculates on the probability of similar success attending *well-regulated* enterprises in Salop, Stafford, and Worcester. He alludes to a great sinking now going on between the edge of the Dudley coal-field and Birmingham, the shafts of which he believes are passing through strata of this age.

The author has defined the whole of the base line of the new red sandstone from May Hill in Gloucestershire to the Oswestry coal-field, and has made some changes in its direction, particularly in the country between Newent and the Malvern Hills, and between Kidderminster and Bridgnorth. He further describes the occurrence of several conglomerates along this base line, the most notable of which are Haffield Camp near Ledbury, Rosemary Rock near Knightwick bridge on the eastern flanks of the Abberley Hills, and on the sides of Stagbury and Warshill Hills near Bewdley. These conglomerates, resembling that of Heavitree in Devonshire, are subordinate to red sandstone, and the fragments of trap which they contain have been derived from hills in their immediate vicinity. Felspathic trap rocks of this character have been formerly described in the Malvern and Abberley Hills, and similar rocks have this year been discovered by the author in Stagbury and Warshill Hills resembling in composition the rocks of the Clent and Abberley Hills. The conglomerates, however, which rest upon their flanks, include fragments of quartz, greywacke, old red sandstone, &c. Though occupying the base line of the series of new red sandstone, the author does not pledge himself that the conglomerates of these districts are the precise equivalents of the lower red sandstones which overlie and pass down into the coal-measures of Shropshire, for he shows that in the south of Worcestershire and in Gloucestershire there is not a sufficient expansion of the system to admit of such proofs. He is, however, disposed to think that the red sandstone which overlies the small patches of coal at Newent, may prove to be the representative of the lower new red. At two or three places on the eastern slopes of the Malvern Hills the conglo-

merates have been observed in inclined positions, and at some height above the adjoining plain. At Great Malvern they adhere in one spot to the steep flank of the sienite in a dislocated form, dipping east at an angle of 30° to 35°. This fact not having been previously noticed is considered to be worthy of record, as leading to the inference, that this chain of trappean hills may have undergone a movement of elevation subsequent to the deposit of the new red sandstone.

A letter was also read from Thomas Weaver, Esq. F.G.S. addressed to George Bellas Greenough, Esq. P.G.S.

In a communication read before the Society on the 4th of June 1830, Mr. Weaver stated that all the coal of the province of Munster except that of the county of Clare, belonged to the transition series*. In this letter he says, "Having devoted between three and four months continuous service to further research in the south of Ireland, I have to retract that statement, having been led to too rapid an inference by the apparent connexion between the southern portion of the coal-field and the transition series; and especially by finding the limestone, which there underlies the coal measures, to contain some fossils hitherto considered distinctive of the transition epoch, in particular the Trilobites, which I have designated, some crinoidal remains, &c. But having in my later researches discovered between that limestone (in a part of its extent) and the transition series, a well-characterized formation of old red sandstone, the anomaly disappears, and we have in regular succession, the old red sandstone, carboniferous limestone, and the coal measures, which last I find also supported in other quarters by the carboniferous limestone, except where they directly conjoin the transition series. I am now, therefore, convinced that both the North and South Munster coal tracts are alone referrible to the great carboniferous order."

LII. *Intelligence and Miscellaneous Articles.*

PREPARATION OF CANTHARIDINE.

M. THIERRY procures this substance by the following process: Reduce cantharides to powder, and digest it for some days either in æther, ætherized alcohol, or alcohol of sp. gr. ·847; the solution is to be separated, the residue washed with more alcohol, and the last portions of alcohol are to be displaced by water. The mixed liquors are to be subjected to distillation; on cooling, numerous small crystals of cantharidine are deposited on the surface of the liquor. This liquor consists of two distinct portions; the upper one is a green oil, which contains the crystallized cantharidine; the lower one is a brown liquor: they are separable by a funnel, and the oil mixed with cantharidine is placed upon a filter, and when heated in a stove, the oil passes through the filter, and the cantharidine remains upon it. The cantharidine thus procured is still mixed with oil, which is to be separated by pressure between folds of paper; the purification is completed by dissolving the cantharidine in boiling alcohol, from which it

* Phil. Mag. and Annals, N.S. vol. viii. p. 148.

is deposited on cooling in the form of scales: the solution in alcohol, with the addition of animal charcoal, is to be repeated.

Cantharidine thus obtained has the following properties: It is inodorous; when heated to 400° Fahr. it melts; and if the heat be continued, it is converted into white vapours, which condense in small crystals on the sides of the vessel.

Concentrated and boiling sulphuric acid dissolves cantharidine; the solution has a light brown colour: when diluted with water, it deposits cantharidine in small needles.

Boiling nitric acid dissolves it without any change of colour; the solution deposits small crystals on cooling, and the same effect is produced by muriatic acid.

Potash and soda dissolve cantharidine; and if concentrated acetic acid be added to these solutions, the cantharidine is deposited in small crystals. Ammonia has no action on cantharidine.

Oil of turpentine, olive oil, and oil of sweet almonds dissolve cantharidine when hot, but it deposits on cooling.—*Journal de Chimie Médicale*, Mars 1835.

GALLIC ACID SPEEDILY PREPARED.

According to Döbereiner, gallic acid may be prepared by mixing a concentrated infusion of galls with acetic acid, in order to decompose the gallate of lime; it is then to be shaken for a few minutes with æther, which takes up much gallic acid; the æther is to be slowly evaporated, and gallic acid is obtained in a very short time in small colourless crystals.—*Ibid.*

PRESERVATION OF DELIQUESCENT SALTS.

M. Druchar recommends that a few drops of oil of turpentine should be put into the bottle, and when it is diffused the deliquescent crystals should be introduced.—*Ibid.*

COMPOSITION OF THE ATMOSPHERE.

M. A. Chevallier is at present occupied with researches on the composition of the atmosphere; he states the following as the results already obtained:

1st. In general, the air of Paris and of many other places contains ammonia and organic matters in solution.

2ndly. If the water deposited from air (dew) by cooling be examined, it is found to contain ammonia and organic matters.

3rdly. The quantity of ammonia contained in the air is often pretty considerable.

4thly. The presence of ammonia is easily explained, because this gas is produced under many circumstances.

5thly. The composition of atmospheric air may vary in certain localities, from a great number of particular circumstances, as the nature of the combustible employed in great masses, the decomposition of animal and vegetable matters, &c. &c. The air of London contains sulphurous acid, that of the sewers of Paris contains acetate and hydrosulphuret of ammonia; air taken from near the *bassins* de Montfauçon contains ammonia and its hydrosulphuret.—*Journal de Pharmacie*, Nov. 1834.

Meteorological Observations made by Mr. THOMPSON at the Garden of the Horticultural Society at Chiswick, near London, and by Mr. VEALL, at Boston.

Days of Month. 1835.	Barometer.			Thermometer.			Wind.		Rain.	
	London.		Boston.	London.		Bost.	Lond.	Bost.	Lond.	Bost.
	Max.	Min.	8½ A.M.	Max.	Min.	8¼ A.M.				
Feb. 1	30·291	30·273	29·80	53	47	45	sw.	w.	...	...
2	30·341	30·167	29·60	56	40	52	sw.	w.	...	0·03
3	30·430	30·400	29·83	53	39	49	sw.	w.	...	...
4	30·531	30·474	29·87	53	39	47·5	w.	calm	...	...
☽ 5	30·256	30·091	29·60	50	34	43	sw.	calm	...	...
6	30·321	30·208	29·67	48	39	35·5	nw.	nw.	...	·08
7	30·089	29·725	29·58	50	41	47	sw.	nw.	...	·06
8	29·818	29·682	29·20	46	34	40	sw.	nw.	...	·18
9	29·980	29·882	29·43	49	32	39	w.	nw.	...	·09
10	30·424	30·180	29·70	41	24	31	n.	n.	...	...
11	30·485	30·329	29·95	45	39	35	sw.	calm	0·18	...
12	30·298	30·166	29·66	47	33	44	n.	calm	·28	·04
○ 13	30·380	30·151	29 82	50	40	42·5	w.	w.	·01	...
14	30·069	29·876	29·55	52	42	42	sw.	calm	·03	...
15	29·713	29·503	29·15	53	39	46	w.	w.	...	·04
16	29·696	29·560	29·13	51	34	40	n.	w.	...	·15
17	29·746	29·709	29·27	52	33	42	nw.	calm	·04	...
18	29·519	29·473	29·	51	27	43·5	sw.	w.	·01	...
19	29·488	29·079	28·98	50	37	38	sw.	w.	·50	·07
☾ 20	29·319	29·039	28·79	50	33	37	w.	w.	·51	·39
21	29·624	29·324	28·82	47	33	36	w.	w.	·01	·10
22	29·790	29·301	29·25	49	41	38	sw.	calm	·29	...
23	29·717	29·272	28·56	49	33	46·5	w.	sw.	...	·26
24	29·914	29·808	29·28	50	34	40	w.	nw.	...	...
25	29·639	29·380	29·05	51	42	47	sw.	w.	·24	·03
26	29·456	29·302	28·74	51	38	45	sw.	sw.	·25	·14
● 27	29·420	29·194	28·69	51	34	43	sw.	sw.	·04	·12
28	29·833	29·668	29·21	46	33	37·5	nw.	nw.	·22	·22
	30·531	29·039	29·32	56	24	41·8			2·61	2·00

Remarks.

London.—Feb. 1. Hazy: overcast. 2. Cloudy and mild. 3—5. Fine. 6. Clear and cold. 7. Cloudy. 8, 9. Clear and fine. 10. Clear and frosty. 11. Overcast. 12. Rain. 13. Fine. 14. Drizzly. 15. Hazy. 16. Fine. 17. Slight rain. 18. Overcast: rain. 19. Clear: cloudy: stormy: and wet at night. 20. Fine: heavy rain at night. 21. Clear and fine. 22. Cloudy: rain. 23. Boisterous: fine at night. 24. Clear and fine. 25—27. Boisterous, with rain. 28. Fine.

Boston.—Feb. 1. Cloudy. 2. Cloudy: rain early A.M. 3. Cloudy. 4. Fine. 5. Fine: stormy with hail and rain A.M.: stormy night. 6. Fine. 7. Cloudy: rain early A.M. 8. Fine: stormy with rain early A.M.: stormy, with rain, hail and lightning P.M. 9. Fine. 10. Fine: stormy with snow early A.M. 11. Cloudy. 12. Cloudy: rain early A.M. 13. Fine. 14. Foggy. 15. Fine: rain early A.M. 16. Fine: rain early A.M. 17, 18. Cloudy. 19. Cloudy: snow 6 A.M.: rain and stormy P.M. 20. Fine: rain P.M. 21. Fine. 22. Fine: rain P.M. 23. Stormy. 24. Fine. 25. Stormy: rain early A.M. 26. Stormy: rain early A.M. and P.M. 27. Stormy: rain P.M. 28. Fine.

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[THIRD SERIES.]

MAY 1835.

LIII. *On* Dr. Ure's *Paper, in the Philosophical Transactions, on the Moira Brine Spring; and on the Proportion of Bromine in the Waters of different Seas.* *By* CHARLES DAUBENY, *M.D., F.R.S., Professor of Chemistry, Oxford.*

To the Editors of the Philosophical Magazine and Journal.

Gentlemen,

IN the second part of the Philosophical Transactions for 1834, is a memoir by Dr. Ure, on the Moira brine spring at Ashby-de-la-Zouch*, which he states to contain in the gallon the following saline ingredients:

	Grs.
Bromide of sodium and magnesium...	8·000
Chloride of calcium	851·000
Chloride of magnesium	16·000
Chloride of sodium	3700·000
Protoxide of iron	a trace
In all	4575·000

As the author has not alluded to the paper published by me in the Transactions for 1830, "On the occurrence of iodine and bromine in certain mineral waters of South Britain," (where he would have found the Ashby waters specified as containing the latter principle,) he does not notice the great discrepancy between the results of his own analysis of this spring, and those of the one I had quoted in my table on the authority of Dr. Thomson of Glasgow.

[* See Lond. and Edinb. Phil. Mag., present vol., p. 58.—EDIT.]

As my own experiments were limited to ascertaining the proportion of bromine present in the water, I have no right to give an opinion as to which analysis deserves a preference; indeed, I should rather regard the want of correspondence between the two as corroborating an idea I have long entertained, that the saline impregnation of mineral springs often undergoes very considerable variation in short intervals of time.

In the autumn of the year 1828, I examined a mineral water then recently discovered at Willoughby, in Warwickshire, which smelt strongly of sulphuretted hydrogen, and which appeared to contain in the gallon no less than 16·9 cubic inches of that gas. In the April following, by the same method of operating, I could detect only 12·65 cubic inches, a difference which I was then disposed to attribute to the greater dilution of the water by the rains that had fallen during the winter. On reexamining the same spring, however, in September of last year, I could discover only 5·2 cubic inches of sulphuretted hydrogen in the gallon, and I am therefore, driven to the conclusion that a difference in point of strength has actually occurred within the period of four or five years. Nevertheless, as even at present the spring appears to be more strongly impregnated with sulphuretted hydrogen than any other in the midland counties, I am glad to take this opportunity of announcing its existence, for the sake of those invalids who may find it inconvenient to resort to Harrogate*.

The same supposition will account for the entire want of correspondence between the results of my analysis of the Gloucester mineral spring stated in the same paper, and those which had previously been given by Mr. Accum.

In the case of the Ashby waters it may be remarked, that three analyses have been made; the first by Mr. Accum, which

* The saline ingredients of this spring in the gallon, in 1828, were as follows:

Carbonate of lime	5·620
——— magnesia	0·175
Chloride of calcium	1·065
——— sodium	5·391
Sulphate of soda	32·800

Or, according to Dr. Murray's views, which suppose the ingredients of a mineral water to be united in such a manner as to form compounds readily soluble:

Carbonate of soda	5·965
——— magnesia	0·175
Chloride of calcium	6·110
Sulphate of lime	0·290
——— soda	32·450

gives in the gallon 72 grains of sulphate of lime, and 128 grains of sulphate of soda; the second by Dr. Thomson, which represents the same quantity as containing only 34 grains of the former salt, and 20 of the latter*; whilst the latest of all, that of Dr. Ure, states the entire absence of all sulphuric salts whatsoever. The quantity of saline matter is also stated very differently by the three analysts.

With regard to the quantity of bromine present, my estimate in 1829 was 4·68 grains in the gallon, Dr. Ure's in 1834, 6 grains, which is perhaps as near a correspondence as, under all the circumstances, can be expected.

With regard to the indirect method of calculating the proportional quantities of bromine and chlorine intermixed, which Dr. Ure has adopted, I may remark, that the very same was proposed by me in an Essay on the Atomic Theory, which I published in the year 1831, (see page 89 of that work,) and that I have even given in page 92, a table of the relative proportions of bromine and chlorine in a given quantity of the silver precipitate, which, if read backwards, will be found to correspond with that given by Dr. Ure in his late paper, allowance being made for the slight difference in the atomic weight of bromine in my calculation and in his.

It is on the above principle that I had begun to calculate the proportion of bromine present in the waters of different seas; and as the opportunities for obtaining sufficiently large quantities occur but rarely, I may take this occasion of mentioning, that a sample of sea water taken just outside of the harbour of Marseilles appeared to contain a larger proportion than that of the British Channel off Cowes.

The latter I had estimated in my Memoir in the Transactions already referred to at about 1 grain in the gallon, but in 1832 I calculated its amount by the method just alluded to at only 0·915 of a grain; whilst in the water of Marseilles, by a similar process, I was led to estimate it at 1·26 of a grain. Yet this did not appear to depend upon a difference in the relative saltness of the two seas, for in the Marseilles water the proportion of salt to water was 3·5 per cent., and in that from the English Channel 3·7.

Neither must it be inferred that the water of the Mediterranean, generally speaking, is richer in bromine than that of the Atlantic, for I have found that some which I lately obtained in the Bay of Naples corresponded almost exactly in this respect with that formerly taken from the neighbourhood of Portsmouth.

* As quoted in Cubitt's Essay on the Mineral Water of Ashby-de-la-Zouch.

Nevertheless, the inquiry as to the existence of local variations in the quantity of bromine, and as to the cause of such variations, is one worth prosecuting; and to those who are favourably circumstanced for such investigations I may venture to recommend the above indirect method of calculating the relative proportions of two intermixed and similar ingredients, which we owe to M. Gay-Lussac; and I do so with greater confidence, now that I find its application to the case in question sanctioned by the adoption of so experienced a chemist as Dr. Ure. I remain, Gentlemen, yours, &c.

Oxford, March 27, 1835. CHARLES DAUBENY.

LIV. *On the Fusion and Appearance of refined and unrefined Copper. By* DAVID MUSHET, *Esq.*

To the Editors of the Philosophical Magazine and Journal.

Gentlemen,

AS you thought my observations on the alloys of iron and copper deserving of insertion in your Magazine (for February last), perhaps you will allow me to forward you a few extracts from experiments made some years ago, with a view to ascertain what effect would be produced upon the strength and malleability of copper by retaining to a certain extent the alloy (chiefly tin) which is found in rough copper and which it is the purpose of the copper-refinery to discharge. In the first place, I obtained a quantity of shotted rough copper, made from the furnace in which the copper, though alloyed with other matters, first appears in its metallic form. These shots were light and flaky, hard when struck, but at the same time partially ductile. A quantity of pure shotted copper made from the refinery, and having the form of flattened spheroids and much denser than the other, was procured at the same time for the purpose of these experiments.

Exp. No. 1. A quantity of rough copper was fused in a black-lead crucible with nearly an equal bulk of charcoal, and poured into an open iron mould. The bar or ingot thus made was $\frac{3}{4}$ths of an inch thick, and when cold and broken, was found to have crystallized in converging striæ perpendicular to the upper and lower surfaces, and declining towards the outer edges of the bar. The grain was of a pale colour inclining to gray, indicating the presence of tin.

Exp. No. 2. Three bars procured in this way were melted together in a black-lead crucible without charcoal, and poured into a mould just at the moment when the melted copper put

on a creamy appearance. When cold, the surface of the ingot thus obtained was less coppery-metallic than the surface of the ingot in the first experiment, where charcoal was used, from which it may be inferred that, owing to the absence of charcoal, a certain degree of refinement had taken place. The fracture possessed more of the red grain of good copper; the striæ were less distinct and less crystalline; and the surface instead of being convex, as in the first experiment, was concave.

Exp. No. 3. Some of the pure shotted copper was fused in a black-lead crucible with an equal bulk of charcoal, and the resulting ingot presented a more clean and perfect mass of copper than the ingots obtained in Experiments No. 1 and No. 2. The fracture presented a series of brilliant striæ arranged from surface to surface, breaking off easily in the direction of the perpendicular fibre; a structure which seems wholly incompatible with extension and malleability.

Exp. No. 4. Some of the same pure copper melted similarly, but not poured into the mould until it had nearly lost its fluidity, formed an ingot less striated or crystallized than any of the former, with more of that minute deep orange-coloured grain which is peculiar to pure and malleable copper. From the results of this experiment, and of No. 2, it would seem that when copper is poured into the mould at as low a temperature as is consistent with perfect fluidity, the fracture is less crystallized, and the colour approximates to that ruby grain which indicates the malleable state of copper.

Four bars, one from each of the foregoing experiments, were imbedded in burnt lime, shut up from the access of air, and exposed in crucibles to the same temperature. The pure copper bars (Nos. 3. and 4.) were on the surface considerably oxidated, but those made from the rough copper (Nos. 1. and 2.) were entirely free from oxide; and from this it may be inferred that the alloy (principally tin) which still remained in the copper prevented waste or oxidation. The bar from Experiment No. 1. was not cut, but that from Experiment No. 2. retained about the same quantity of grained striæ as before the cementation; though, compared with a fracture of the same copper that had not been cemented, the grain was redder, the colour more brilliant, and the metal more ductile. The bar from Experiment No. 3. was covered with a thin coating of crystallized oxide exceedingly soft; the striæ were more enlarged and adhesive, so that the copper, in cutting, tore out in flakes, which separately were soft and ductile. The bar from No. 4. when examined and compared with an uncemented one was more open in the grain, redder, and more brilliant;

but the quantity or depth of grain was nowise altered, although the metal cut softer, and was covered with a thin crust of shining oxide. From these details it may be presumed that cementation opens the grain, renders the bar less dense, but does not change the peculiar form of the arrangement. In each case the copper after cementation was softer, a change which seems favourable to rolling cold. The impure or rough copper appears to be alloyed with another metal (no doubt tin), which prevents that oxidation which pure copper in the same circumstances would undergo.

Besides the above, several bars were made from the rough copper by a slower fusion, and with a longer exposure to the charcoal; and it was observable that the longer the exposure, and the slower the fusion, the more yellow and refined was the copper in the bar.

Some of the bars produced in the course of these experiments were attempted to be rolled; but the success was various. Of those made from the pure copper, some rolled better and others worse than any made from the rough copper: one or two bars of the latter were equally malleable with the former; but none rolled well either hot or cold. In those bars in which the striated arrangement was most perfect, the capacity for rolling was least, and those in which the minute granular fracture prevailed, generally rolled the best. It certainly does appear that this tendency to crystallize, so destructive to malleability, is peculiar to English copper made from the crucible. There are occasions, no doubt, when, the proper temperature being hit upon, the bar would roll; but these occasions are so rare and uncertain that English copper made in this manner could not be relied upon in the manipulations connected with manufactures. There is no question that the arts in this country suffer from the peculiarity of English copper. For in consequence of it the malleabilization of that metal is necessarily confined to the original process of refining practised on the great scale by the copper smelters. It is very different with Swedish and Russian copper, which I have seen melted in considerable quantities in large crucibles, cast into cakes or thick sheets, and afterwards rolled into boiler plate and thin sheet copper. This subject requires and deserves a scrutinous examination, with a view to discover the cause of the uniform tendency of English copper to crystallize; and that cause may, perhaps, be found in the process employed in this country for the smelting of copper ores, a process which, however œconomical and well calculated to overcome quantity, has never yet produced pure copper.

Should these remarks obtain a place in your Magazine,

I will, when at leisure, send you some details of experiments made with rough and pure copper exposed to the action of muriatic acid. I am, Sir, yours, &c.

David Mushet.

LV. *On Water as a Constituent of Salts. In the Case of Sulphates. By* Thomas Graham, *F.R.S.E., Andersonian Professor of Chemistry and Vice-President of the Philosophical Society of Glasgow.**

It may be useful to distinguish some of the functions which water is already admitted to discharge in the constitution of hydrated salts.

Every salt of ammonia with an oxygen acid contains an atom of water, and cannot exist without it. The state of combination of the water is peculiar, and has been represented by supposing that the elements of ammonia unite with the hydrogen of the water, and form a new compound radical, to which the name ammonium is given, while the oxygen of the water unites with this radical, and produces oxide of ammonium. Hence nitrate of ammonia, in which there exist the elements of one atom of nitric acid, of ammonia, and of water, is viewed as anhydrous nitrate of the oxide of ammonium, and corresponds with nitre or the nitrate of the oxide of potassium. But it is not the object of this paper to discuss particularly the state of water in the ammoniacal salts.

We have it often in the crystals of salts, united by a feeble affinity, and known under the name of water of crystallization. The number of atoms of water with which some salts unite, in crystallizing from a state of solution, is affected by temperature, and other slight causes. This water is commonly viewed as a constituent of salts which is not essential, owing to the facility with which it may in general be expelled by heat, and also to the circumstance that many salts usually hydrated, are likewise capable of existing in a crystalline state without water.

In the hydrates of the caustic alkalies and of the earths, water is retained by a strong affinity, and is generally supposed to be united, like an acid, to the alkali or earth. In such hydrates, water discharges an *acid* function.

In the case of hydrates of the acids, the portion of water which is found to be inseparable by heat, or to be very strongly retained, has generally been presumed to be in the place of a base to the acid, although little attention has been

* From the Transactions of the Royal Society of Edinburgh, vol. xiii. Part I. recently published: revised by the Author.

paid to the subject. The most highly concentrated sulphuric acid retains one atom of water, and is supposed to be a sulphate of water. In the case, too, of such a supersalt as bisulphate of potash or bitartrate of potash, the single atom of water which is known to be persistently attached to the salt, has been viewed of late, by our most enlightened chemical theorists, as essential to its constitution, and the possibility admitted that such salts may really be *double salts*; the bisulphate of potash, a sulphate of potash combined with sulphate of water, and the bitartrate of potash, a tartrate of potash combined with tartrate of water.

In a late publication I have developed this view of water acting as a base in the case of phosphoric acid*. That acid is capable of combining with water in three different proportions; and the number of atoms of water with which the acid combines at any time, depends upon circumstances which are understood. That the water is basic in these different hydrates, follows from the fact, that, on treating them with an alkali, the water is constantly replaced by a quantity of alkali chemically equivalent to the water. By nitrate of silver, the same precipitate is thrown down from any phosphate of soda and from the corresponding phosphate of water; the composition of the precipitate being determined in both cases by the same double decomposition. The peculiarity of phosphoric acid is, that it is capable of uniting with water as a base, in several proportions, while all other acids combine with water as a base in one proportion only, so far as is yet known. By these discoveries in regard to phosphoric acid and its salts, the ordinary conceptions entertained of the constitution of salts were completely deranged. The salts called biphosphate of soda, phosphate of soda, and subphosphate of soda, are all tribasic salts. The common idea of a supersalt is inapplicable to any of them.

I have subsequently found water to exist in a different state in certain salts, not possessed of a true basic function, being replaceable by a *salt*, and not by an alkaline base. To illustrate this new function of water as a constituent of salts, is my principal object in the present communication.

The tendency of phosphate of soda to unite with an additional dose of soda, and form a subsalt, I had traced to the existence of basic water in the former. The inquiry suggested itself, Is there any analogous provision in the constitution of such salts as have a tendency to combine with other

* [Abstracts of Prof. Graham's papers on this subject published in the Philosophical Transactions, will be found in Lond. and Edinb. Phil. Mag., vol. iii. pp. 451, 459: see also his "Reply to Mr. Phillips's Additional Observations on Chemical Symbols," in vol. v. p. 401.—Edit.]

salts, and to form double salts? The salts which combine together most readily are the sulphates, and to these I therefore turned. The result was, that in that well-known class of sulphates, consisting of sulphates of magnesia, zinc, iron, manganese, copper, nickel, and cobalt, all of which crystallize with either five or seven atoms of water, one atom proved to be much more strongly united to the salt than the other four or six, which last generally may be expelled by a heat under the boiling-point of water, while the remaining atom uniformly requires a heat above 400° Fahrenheit, for its expulsion, and seems to be in a manner essential to the salt. The constitution of crystallized sulphate of zinc, for instance, may be expressed thus:

$$\dot{Zn}\dddot{S}\dot{H}+\dot{H}^{6}$$

We here divide the seven atoms of water—into one atom, which is essential to the constitution of the salt as we know it,—and six atoms which are not so; and to this last quantity we may restrict the application of the name "water of crystallization." Now, in the double sulphate of zinc and potash, the single atom of water in question pertaining to the sulphate of zinc is replaced by an atom of sulphate of potash, and the six atoms of water of crystallization remain. Sulphate of magnesia combines with sulphate of potash after the same manner, and so do all the other salts of the class. The constitution of the crystallized sulphate of zinc and potash, which may be taken as the type of this family of double salts, is therefore represented by the following formula,

$$\dot{Zn}\dddot{S}(\dot{K}\dddot{S})+\dot{H}^{6};$$

which differs only from the previous formula in having the sign of sulphate of potash ($\dot{K}\dddot{S}$) substituted for the sign ($\dot{H}$) of the essential atom of water.

From a contemporaneous examination of the supersulphates, the conclusion proved to be inevitable, that they also are double salts; that the bisulphate of potash, for instance, is a sulphate of water and potash, and that its formula is as follows,

$$\dot{H}\dddot{S}(\dot{K}\dddot{S}),$$

with or without water of crystallization in addition. There is likewise a provision in the constitution of hydrated sulphuric acid for the production of such a double salt, as in the case of the sulphate of zinc. Hydrated sulphuric acid of specific gravity 1·78 contains two atoms of water, and is capable of crystallizing at a temperature so high as 40° Fahrenheit. It

is the only known crystallizable hydrate of sulphuric acid. It may be represented by the formula,

$$\dot{H}\dddot{S}\dot{H},$$

$$\dot{Zn}\dddot{S}\dot{H},$$

which may be compared with that of sulphate of zinc placed below it. This second atom of water present in hydrated sulphuric acid, is replaceable by sulphate of potash, a salt; and the bisulphate of potash results from the substitution. But the first atom of water in the acid hydrate can be replaced only by an alkali or true base. The function of the first atom is *basic*, but a new term is required to distinguish the function of the second atom of water, or of the essential atom of water in the sulphate of zinc. The application of the epithet *saline* to that atom of water, may, perhaps, be permitted, to indicate that it stands in the place of a salt. The hydrate of sulphuric acid in question contains, therefore, an atom of basic, and an atom of saline water. It is "a sulphate of water with saline water," as the hydrous sulphate of zinc is "a sulphate of zinc with saline water." The bisulphate of potash also is "a sulphate of water with sulphate of potash," and corresponds with the sulphate of zinc and potash; which last is "a sulphate of zinc with sulphate of potash."

A reason could now be given why there exist no supersulphates (or indeed any supersalts) of magnesia, zinc, &c. A bisulphate of magnesia would be a compound of sulphate of water with sulphate of magnesia, on our view of supersulphates. Now sulphate of magnesia, and sulphate of water, are bodies of analogous constitution, or of the same category, and should have as little disposition to combine together, as sulphate of zinc and sulphate of magnesia have.

1. *Sulphate of Water with Saline Water:* $\dot{H}\dddot{S}\dot{H}$. *Sulphuric Acid of sp. gr.* 1·78.

It appears, then, that in an exposition of the relations of the sulphates, we may set out from this body as our primary sulphate. Of the two atoms of water which it contains, that atom which is basic cannot be separated from the acid, unless by the agency of a stronger base. The second, or saline atom of water, may be separated by heat, but not by any degree of heat under 400° Fahrenheit, and is re-absorbed with great avidity.

A diluted sulphuric acid may, I find, be concentrated at a temperature not exceeding 380°, without the loss of a particle of acid; and the quantity of water retained is reduced to two

atoms most precisely. This in fact is an exact method of obtaining the definite sulphate of water with saline water; which may be kept at 380° or 390°, without sustaining any further loss. I have observed a close approximation to the same proportion of water, even in the case of a dilute acid concentrated at a temperature not exceeding 300°. But at 400° or 410°, this hydrate begins to be decomposed, and a portion of it is apt to distill over with the water expelled. When, however, this hydrate is distilled *in vacuo*, at the last-mentioned temperature, it loses nothing but water for some time.

In one experiment, a small quantity of dilute sulphuric acid was found to concentrate down to three atoms of water, at a temperature not exceeding 212°, at which it was sustained *in vacuo* for not less than forty hours. It consisted of 100 parts dry acid united with 68·07 water, while three atomic proportions of water are 67·32 parts.

The concentrated acid of commerce, which is a definite sulphate of water, without the saline atom, does not freeze at a temperature so low as −36°, according to Dr. Thomson. To sulphuric acid of sp. gr. 1·78, I added water in the proportion of two, four, and six atoms; but all these hydrates remained fluid, when kept for a short time at 0° Fahrenheit. Anhydrous sulphate of magnesia or zinc never dissolves, *as such*, in water; or exhibits any determinate chemical character. It must always combine with its saline atom of water in the first instance, or with something equivalent, and it is the compound which is soluble, &c. So it is with the sulphate of water, or concentrated sulphuric acid ($\dot{H}\dddot{S}$). In chemical character it is an *incomplete body*. There is a hiatus in its constitution, which must be filled up. When it dissolves in any menstruum, we may be sure that it has first acquired its second or saline atom of water, or something in its place. Hence a set of reactions of sulphuric acid, which are peculiar to its concentrated condition, upon alcohol and many organic bodies. But to this peculiar state of bodies I shall again have occasion to allude under sulphate of lime, a body which illustrates it more strikingly than the sulphate of water.

Sulphate of Water with Sulphate of Potash: $\dot{H}\dddot{S}(\dot{K}\dddot{S})$. *Bisulphate of Potash.*

Of all the sulphates, the acid sulphates or bisulphates of potash and soda deviate least from the primary sulphate of water. We have, in the one case, merely sulphate of potash; and, in the other, sulphate of soda, substituted for the saline atom of water of the sulphate of water. In none of the speci-

mens of these salts which I had occasion to examine, was there any water of crystallization, and the evidence which is given of its occasional presence is of a very doubtful description. The crystals could be heated to 300°, without impairing their transparency; and they fused at a temperature not under 600°, without the loss of anything, except a trace of water, which had been mechanically retained. Upon heating a bisulphate nearly to redness, a portion of sulphate of water is expelled. I greatly doubt whether water ever comes off in such a case unaccompanied by sulphuric acid, although Berzelius appears to be of a different opinion. It is well known that the sulphate of water is not entirely expelled from these salts by heat alone, even the most intense. Sulphate of water, however, leaves the sulphate of soda with greater facility than it leaves the sulphate of potash.

These sulphates should be crystallized from concentrated solutions at a high temperature; for their solutions are very apt to undergo decomposition at low temperatures, the neutral sulphate crystallizing, and leaving "the sulphate of water with saline water" in solution. I have often observed this decomposition to occur, even in solutions containing a great excess of sulphuric acid. At low temperatures, therefore, the affinity of sulphate of water for "saline water," prevails over its affinity for sulphate of potash. Crystals of bisulphate of soda, pounded and put under pressure in blotting paper, are apt to undergo the same decomposition, if the air is damp, and frequently impart a large quantity of their sulphate of water to the paper in the course of twenty-four hours. This circumstance must be kept in view in preparing bisulphates for analysis. The facility with which these salts are decomposed by water, accords well with their relation to sulphate of water with saline water, which we have supposed to exist. Sulphate of zinc, sulphate of magnesia, &c. are capable of separating the sulphate of water from these salts, at a temperature approaching to redness, and take its place.

I have observed that the bisulphate of soda is more prone to decomposition, when dissolved in water, than the bisulphate of potash. The double salts of sulphate of soda with sulphate of magnesia, &c., are also much less stable than the corresponding double salts containing sulphate of potash. Indeed, I believe that the former are uniformly decomposed when dissolved in water.

Sulphate of Potash, Sulphate of Soda. $\dot{K}\dddot{S}$, $\dot{Na}\dddot{S}$.

These salts differ from other sulphates in having no saline water. Of the ten atoms water with which sulphate of soda

crystallizes, none is essential to its constitution. The whole were lost, even at a temperature not exceeding 47° Fahrenheit, when the crystals of the salt were exposed over sulphuric acid *in vacuo* for five days. From the regular progress of the desiccation of the salt, which was observed by occasionally weighing it, it was evident that no portion of the water was more strongly retained than the rest. It is well known that sulphate of soda crystallizes in an anhydrous condition from a hot solution.

Sulphate of Zinc with Saline Water: $\dot{\mathrm{Z}}\mathrm{n}\dddot{\mathrm{S}}\dot{\mathrm{H}}+\dot{\mathrm{H}}^{6}$. *Sulphate of Zinc.*

In the sulphate of zinc, we have the basic atom of water contained in sulphate of water displaced by oxide of zinc, while the saline atom remains; and to this compound six atoms of water are attached in the common crystals. These crystals, placed over sulphuric acid *in vacuo*, thermometer 68°, were found to lose six atoms water, retaining only one. Exposed to the air at 212°, the crystals likewise readily effloresced down to one atom; and the sulphate of zinc is known to be deposited from a boiling solution in crystalline grains, containing one atom of water. On the other hand, the sulphate of zinc was found to retain this single atom of water at the high temperature of 410° Fahrenheit, but to lose it, and become anhydrous, at a temperature not exceeding 460°. In all such cases, the hydrated salt was heated in a tube receiver, by means of an oil- or solder-bath, of which the temperature was observed by a thermometer. However strongly it has been heated, without being decomposed, the sulphate of zinc always regains this atom of water when moistened, slaking with the evolution of heat. Common sulphate of zinc is therefore "sulphate of zinc with saline water;" and the true or absolute sulphate of zinc is unknown to us in the crystalline form, or in a soluble state. But we may continue to designate the salt we possess as sulphate of zinc, as the name is attended with no dubiety.

Sulphate of Zinc with Sulphate of Potash: $\dot{\mathrm{Z}}\mathrm{n}\dddot{\mathrm{S}}(\dot{\mathrm{K}}\dddot{\mathrm{S}})+\dot{\mathrm{H}}^{6}$. *Sulphate of Zinc and Potash.*

In this well-known double salt, we have sulphate of potash substituted for the saline water of sulphate of zinc, and the six atoms of water of crystallization remain. It is readily formed, on mixing together solutions of sulphate of zinc and sulphate of potash, in atomic proportions. It is formed likewise, and separates by crystallization, when the sulphate of zinc is added to the bisulphate of potash; and, in that case, an interesting double decomposition occurs.

Sulphate of zinc with saline water, Sulphate of water with sulphate of potash,	yield	Sulphate of zinc with sulphate of potash. Sulphate of water with saline water.

In the sulphate of zinc and potash, the whole six atoms of water are retained with considerably greater force than in the sulphate of zinc itself; but even the double salt becomes anhydrous at 250°, and, indeed, the water retained falls below a single atomic proportion, when the salt is dried *in vacuo* over sulphuric acid, at a temperature not exceeding 78° Fahrenheit. The sulphate of potash in the double salt has not the effect of neutralizing the acid reaction of sulphate of zinc, according to my observations; nor has it that effect in the case of any other double salt.

I subjoin a table of observations, made on the quantity of water retained by this double salt, in different circumstances. In the first two columns, the composition of the quantities actually examined is stated in grains.

	Anhydrous Salt.	Water.	Anhydrous Salt.	Water.
Dried *in vacuo* over sulphuric acid for ten days, temp. from 68° to 78°	17·2	0·68	100	3·95
Nine hours, at 238°	19·03	1·33	100	6·99
Two hours at 250°, and one hour at 270°	7·79	0·	100	0·
Four hours at 250°	6·55	0·	100	0·
Composition of sulphate of zinc and potash with one atom water (by theory) ...	...	...	100	5·37

[To be continued.]

LVI. *Experimental Researches in Electricity.—Eighth Series. By* Michael Faraday, *D.C.L. F.R.S. Fullerian Prof. Chem. Royal Institution, Corr. Memb. Royal and Imp. Acadd. of Sciences, Paris, Petersburgh, Florence, Copenhagen, Berlin, &c. &c.*

[Continued from p. 279.]

¶ iii. *On associated Voltaic Circles, or the Voltaic Battery.*

989. PASSING from the consideration of single circles (875. &c.) to their association in the voltaic battery, it is a very evident consequence, that if matters are so arranged

that two sets of affinities, in place of being opposed to each other as in figg. 1, 4. (880. 891.), are made to act in conformity, then, instead of either interfering with the other, it will rather assist it. This is simply the case of two voltaic pairs of metals arranged so as to form one circuit. In such arrangements the activity of the whole is known to be increased, and when ten, or a hundred, or any larger number of such alternations are placed in conformable association with each other, the power of the whole becomes proportionably exalted, and we obtain that magnificent instrument of philosophic research, the *voltaic battery.*

990. But it is evident from the principles of definite action already laid down, that the *quantity* of electricity in the current cannot be increased with the increase of the *quantity of metal* oxidized and dissolved at each new place of chemical action. A single pair of zinc and platina plates throws as much electricity into the form of a current, by the oxidation of 32·5 grains of the zinc (868.) as would be given by the same alteration of a thousand times that quantity, or nearly five pounds of metal oxidized at the surface of the zinc plates of a thousand pairs placed in regular battery order. For it is evident, that the electricity which passes across the acid from the zinc to the platina in the first cell, and which has been associated with, or even originated by, the decomposition of a definite portion of water in that cell, cannot pass from the zinc to the platina across the acid in the second cell, without the decomposition of the same quantity of water there, and the oxidation of the same quantity of zinc by it (924. 949.). The same result recurs in every other cell; the electro-chemical equivalent of water must be decomposed in each, before the current can pass through it; for the quantity of electricity passed, and the quantity of electrolyte decomposed, *must* be the equivalents of each other. The action in each cell, therefore, is not to increase the quantity set in motion in any one cell, but to aid in urging forward that quantity, the passing of which is consistent with the oxidation of its own zinc; and in this way it exalts that peculiar property of the current which we endeavour to express by the term *intensity*, without increasing the *quantity* beyond that which is proportionate to the quantity of zinc oxidized in any single cell of the series.

991. To prove this, I arranged ten pairs of amalgamated zinc and platina plates with dilute sulphuric acid in the form of a battery. On completing the circuit, all the pairs acted and evolved gas at the surfaces of the platina. This was collected and found to be alike in quantity for each plate; and the quantity of hydrogen evolved at any one platina plate was

in the same proportion to the quantity of metal dissolved from any one zinc plate, as was given in the experiment with a single pair (864. &c.). It was therefore certain, that, just as much electricity and no more had passed through the series of ten pair of plates as had passed through, or would have been put into motion by, any single pair, notwithstanding that ten times the quantity of zinc had been consumed.

992. This truth has been proved also long ago in another way, by the action of the evolved current on a magnetic needle; the deflecting power of one pair of plates in a battery being equal to the deflecting power of the whole, provided the wires used be sufficiently large to carry the current of the single pair freely; but the *cause* of this equality of action could not be understood whilst the definite action and evolution of electricity (783. 869.) remained unknown.

993. The superior decomposing power of a battery over a single pair of plates is rendered evident in two ways. Electrolytes held together by an affinity so strong as to resist the action of the current from a single pair, yield up their elements to the current excited by many pairs; and that body which is decomposed by the action of one or of few pairs of metals, &c., is resolved into its *ions* the more readily as it is acted upon by electricity urged forward by many alternations.

994. Both these effects are, I think, easily understood. Whatever *intensity* may be, (and that must of course depend upon the nature of electricity, whether it consist of a fluid or fluids, or of vibrations of an æther, or any other kind or condition of matter,) there seems to be no difficulty in comprehending that the *degree* of intensity at which a current of electricity is evolved by a first voltaic element, shall be increased when that current is subjected to the action of a second voltaic element, acting in conformity and possessing equal powers with the first: and as the decompositions are merely opposed actions, but exactly of the same kind as those which generate the current (917.), it seems to be a natural consequence, that the affinity which can resist the force of a single decomposing action shall be unable to oppose the energies of many decomposing actions, operating conjointly, as in the voltaic battery.

995. That a body which can give way to a current of feeble intensity should give way more freely to one of stronger force, and yet involve no contradiction to the law of definite electrolytic action, is perfectly consistent. All the facts and also the theory I have ventured to put forth, tend to show that the act of decomposition opposes a certain force to the passage of

the electric current; and that this obstruction should be overcome more or less readily, in proportion to the greater or less intensity of the decomposing current, is in perfect consistency with all our notions of the electric agent.

996. I have elsewhere (947.) distinguished the chemical action of zinc and dilute sulphuric acid into two portions; that which, acting effectually on the zinc, evolves hydrogen at once upon its surface, and that which, producing an arrangement of the chemical forces throughout the electrolyte present, (in this case water,) tends to take oxygen from it, but cannot do so unless the electric current consequent thereon can have free passage, and the hydrogen be delivered elsewhere than against the zinc. The electric current depends altogether upon the second of these; but when the current can pass, by favouring the electrolytic action it tends to diminish the former and increase the latter portion.

997. It is evident, therefore, that when ordinary zinc is used in a voltaic arrangement, there is an enormous waste of that power which it is the object to throw into the form of an electric current; a consequence which is put in its strongest point of view when it is considered that three ounces and a half of zinc, properly oxidized, can circulate enough electricity to decompose nearly one ounce of water, and cause the evolution of about 2400 cubic inches of hydrogen gas. This loss of power not only takes place during the time the electrodes of the battery are in communication, being then proportionate to the quantity of hydrogen evolved against the surface of any one of the zinc plates, but includes also *all* the chemical action which goes on when the extremities of the pile are not in communication.

998. This loss is far greater with ordinary zinc than with the pure metal, as M. de la Rive has shown*. The cause is, that when ordinary zinc is acted upon by dilute sulphuric acid, portions of copper, lead, cadmium, or other metals which it may contain, are set free upon its surface; and these, being in contact with the zinc, form small but very active voltaic circles, which cause great destruction of the zinc and evolution of hydrogen, apparently upon the zinc surface, but really upon the surface of these accidental metals. In the same proportion as they serve to discharge or convey the electricity back to the zinc, do they diminish its power of producing an electric current which shall extend to a greater distance across the acid, and be discharged only through the copper or pla-

* Quarterly Journal of Science, 1831, p. 388; or *Bibliotheque Universelle*, 1830, p. 391. [Also Phil. Mag. and Annals, N.S., vol. viii. p. 298.—Edit.]

tina plate which is associated with it for the purpose of forming a voltaic apparatus.

999. All these evils are removed by the employment of an amalgam of zinc in the manner recommended by Mr. Kemp*, or the use of the amalgamated zinc plates of Mr. Sturgeon (863.), who has himself suggested and objected to their application in galvanic batteries; for he says, "Were it not on account of the brittleness and other inconveniences occasioned by the incorporation of the mercury with the zinc, amalgamation of the zinc surfaces in galvanic batteries would become an important improvement; for the metal would last much longer, and remain bright for a considerable time, even for several successive hours; essential considerations in the employment of this apparatus†."

1000. Zinc so prepared, even though impure, does not sensibly decompose the water of dilute sulphuric acid, but still has such affinity for the oxygen, that the moment a metal which, like copper or platina, has little or no affinity, touches it in the acid, action ensues, and a powerful and abundant electric current is produced. It is probable that the mercury acts by bringing the surface, in consequence of its fluidity, into one uniform condition, and preventing those differences in character between one spot and another which are necessary for the formation of the minute voltaic circuits referred to (998.). If any difference does exist at the first moment, with regard to the proportion of zinc and mercury, at one spot on the *surface*, as compared with another, that spot having the least mercury is first acted on, and, by solution of the zinc, is soon placed in the same condition as the other parts, and the whole plate rendered superficially uniform. One part cannot, therefore, act as a discharger to another; and hence *all* the chemical power upon the water at its surface is in that equable condition (949.), which, though it tends to produce an electric current through the liquid to another plate of metal which can act as a discharger (950.), presents no irregularities by which any one part, having weaker affinities for oxygen, can act as a discharger to another. Two excellent and important consequences follow upon this state of the metal. The first is, that the *full equivalent* of electricity is obtained for the oxidation of a certain quantity of zinc; the second, that a battery constructed with the zinc so prepared, and charged with

* Jameson's Edinburgh Journal, October 1828.

† Recent Experimental Researches, p. 42, &c. Mr. Sturgeon is of course unaware of the definite production of electricity by chemical action, and is in fact quoting the experiment as the strongest argument *against* the chemical theory of galvanism.

dilute sulphuric acid, is active only whilst the electrodes are connected, and ceases to act or be acted upon by the acid the instant the communication is broken.

1001. I have had a small battery of ten pairs of plates thus constructed, and am convinced that arrangements of this kind will be very important, especially in the development and illustration of the philosophical principles of the instrument. The metals I have used are amalgamated zinc and platina, connected together by being soldered to platina wires, the whole apparatus having the form of the *couronne des tasses*. The liquid used was dilute sulphuric acid of sp. gr. 1·25. No action took place upon the metals except when the electrodes were in communication, and then the action upon the zinc was only in proportion to the decomposition in the experimental cell; for when the current was retarded there, it was retarded also in the battery, and no waste of the powers of the metal was incurred.

1002. In consequence of this circumstance, the acid in the cells remained active for a very much longer time than usual. In fact, time did not tend to lower it in any sensible degree; for whilst the metal was preserved to be acted upon at the proper moment, the acid also was preserved almost at its first strength. Hence a constancy of action far beyond what can be obtained with the use of common zinc.

1003. Another excellent consequence was the renewal, during the interval of rest between two experiments, of the first and most efficient state. When an amalgamated zinc and a platina plate, immersed in dilute sulphuric acid, are first connected, the current is very powerful, but instantly sinks very much in force, and in some cases actually falls to only an eighth or a tenth of that first produced (1036.). This is due to the acid which is in contact with the zinc becoming neutralized by the oxide formed; the continued quick oxidation of the metal being thus prevented. With ordinary zinc, the evolution of gas at its surface tends to mingle all the liquid together, and thus bring fresh acid against the metal, by which the oxide formed there can be removed. With the amalgamated zinc battery, at every cessation of the current, the saline solution against the zinc is gradually diffused amongst the rest of the liquid; and upon the renewal of the contact with the electrodes, the zinc plates are found most favourably circumstanced for the production of a ready and powerful current.

1004. It might at first be imagined that amalgamated zinc would be much inferior in force to common zinc, because of the lowering of its energy, which the mercury might be sup-

posed to occasion over the whole of its surface; but this is not the case. When the electric currents of two pairs of platina and zinc plates were opposed, the difference being that one of the zincs was amalgamated and the other not, the current from the amalgamated zinc was most powerful, although no gas was evolved against it, and much was evolved at the surface of the unamalgamated metal. Again, as Davy has shown*, if amalgamated and unamalgamated zinc be put in contact, and dipped into dilute sulphuric acid, or other exciting fluids, the former is positive to the latter, *i. e.* the current passes from the amalgamated zinc, through the fluid, to the unprepared zinc. This he accounts for by supposing that "there is not any inherent and specific property in each metal which gives it the electrical character, but that it depends upon its peculiar state—on that form of aggregation which fits it for chemical change."

1005. The superiority of the amalgamated zinc is not, however, due to any such cause, but is a very simple consequence of the state of the fluid in contact with it; for as the unprepared zinc acts directly and alone upon the fluid, whilst that which is amalgamated does not, the former (by the oxide it produces) quickly neutralizes the acid in contact with its surface, so that the progress of oxidation is retarded, whilst, at the surface of the amalgamated zinc, any oxide formed is instantly removed by the free acid present, and the clean metallic surface is always ready to act with full energy upon the water. Hence its superiority (1037.).

1006. The progress of improvement in the voltaic battery and its applications, is evidently in the contrary direction at present to what it was a few years ago; for in place of increasing the number of plates, the strength of acid, and the extent altogether of the instrument, the change is rather towards its first state of simplicity, but with a far more intimate knowledge and application of the principles which govern its force and action. Effects of decomposition can now be obtained with ten pairs of plates (417.), which required five hundred or a thousand pairs for their production in the first instance. The capability of decomposing fused chlorides, iodides, and other compounds, according to the law before established (380. &c.), and the opportunity of collecting certain of the products, without any loss, by the use of apparatus of the nature of those already described (789. 814. &c.), render it probable that the voltaic battery may become a useful and even œconomical manufacturing instrument; for theory evidently indicates that an equivalent of a rare substance may

* Philosophical Transactions, 1826, p. 405. [or Phil. Mag. and Annals, N.S., vol. i. p. 102.—Edit.]

be obtained at the expense of three or four equivalents of a very common body, namely, zinc: and practice seems thus far to justify the expectation. In this point of view I think it very likely that plates of platina or silver may be used instead of plates of copper with advantage, and that then the evil arising occasionally from solution of the copper, and its precipitation on the zinc, (by which the electro-motive power of the zinc is so much injured,) will be avoided (1047.).

¶ iv. *On the Resistance of an Electrolyte to Electrolytic Action, and on Interpositions.*

1007. I have already illustrated, in the simplest possible form of experiment (891. 910.), the resistance established at the place of decomposition to the force active at the exciting place. I purpose examining the effects of this resistance more generally; but it is rather with reference to their practical interference with the action and phænomena of the voltaic battery, than with any intention at this time to offer a strict and philosophical account of their nature. Their general and principal cause is the resistance of the chemical affinities to be overcome; but there are numerous other circumstances which have a joint influence with these forces (1034. 1040. &c.), each of which would require a minute examination before a correct account of the whole could be given.

1008. As it will be convenient to describe the experiments in a form different to that in which they were made, both forms shall first be explained. Plates of platina, copper, zinc, and other metals, about three quarters of an inch wide and three inches long, were associated together in pairs by means of platina wires to which they were soldered, (Plate I.) fig. 16, the plates of one pair being either alike or different, as might be required. These were arranged in glasses, fig. 17, so as to form Volta's crown of cups. The acid or fluid in the cups never covered the whole of any plate: and occasionally small glass rods were put into the cups, between the plates, to prevent their contact. Single plates were used to terminate the series and complete the connexion with a galvanometer, or with a decomposing apparatus (899. 968. &c.), or both. Now if fig. 18 be examined and compared with fig. 19, the latter may be admitted as representing the former in its simplest condition; for the cups i, ii, and iii of the former, with their contents, are represented by the cells i, ii, and iii of the latter, and the metal plates Z and P of the former by the similar plates represented Z and P in the latter. The only difference, in fact, between the apparatus, fig. 18, and the trough represented fig. 19, is that twice the quantity of surface of contact

between the metal and acid is allowed in the first to what would occur in the second.

1009. When the extreme plates of the arrangement just described, fig. 18, are connected metallically through the galvanometer *g*, then the whole represents a battery consisting of two pairs of zinc and platina plates urging a current forward, which has, however, to decompose water unassisted by any direct chemical affinity before it can be transmitted across the cell iii, and therefore before it can circulate. This decomposition of water, which is opposed to the passage of the current, may as a matter of convenience be considered as taking place either against the surfaces of the two platina plates which constitute the electrodes in the cell iii, or against the two surfaces of that platina plate which separates the cells ii and iii, fig. 19, from each other. It is evident that if that plate were away, the battery would consist of two pairs of plates and two cells, arranged in the most favourable position for the production of a current. The platina plate therefore, which being introduced as at *x*, has oxygen evolved at one surface and hydrogen at the other (that is, if the decomposing current passes), may be considered as the cause of any obstruction arising from the decomposition of water by the electrolytic action of the current; and I have usually called it the interposed plate.

1010. In order to simplify the conditions, dilute sulphuric acid was first used in all the cells, and platina for the interposed plates; for then the initial intensity of the current which tends to be formed is constant, being due to the power which zinc has of decomposing water; and the opposing force of decomposition is also constant, the elements of the water being unassisted in their separation at the interposed plates by any affinity or secondary action at the electrodes (744.), arising either from the nature of the plate itself or the surrounding fluid.

1011. When only one voltaic pair of zinc and platina plates were [was] used, the current of electricity was entirely stopped to all practical purposes by interposing one platina plate, fig. 20, *i. e.* by requiring of the current that it should decompose water, and evolve both its elements, before it should pass. This consequence is in perfect accordance with the views before given (910. 917. 973.). For as the whole result depends upon the opposition of forces at the places of electric excitement and electro-decomposition, and as water is the substance to be decomposed at both before the current can move, it is not to be expected that the zinc should have such powerful attraction for the oxygen, as not only to be able to take it from

its associated hydrogen, but leave such a surplus of force as, passing to the second place of decomposition, should be there able to effect a second separation of the elements of water. Such an effect would require that the force of attraction between zinc and oxygen should under the circumstances be *at least* twice as great as the force of attraction between the oxygen and hydrogen.

1012. When two pairs of zinc and platina exciting plates were used, the current was also practically stopped by one interposed platina plate: fig. 21. There was a very feeble effect of a current at first, but it ceased almost immediately. It will be referred to, with many other similar effects, hereafter (1017.).

1013. Three pairs of zinc and platina plates, fig. 22, were able to produce a current which could pass an interposed platina plate, and effect the electrolyzation of water in cell iv. The current was evident, both by the continued deflexion of the galvanometer, and the production of bubbles of oxygen and hydrogen at the electrodes in cell iv. Hence the accumulated surplus force of these plates of zinc, which are active in decomposing water, is more than equal, when added together, to the force with which oxygen and hydrogen are combined in water, and is sufficient to cause the separation of these elements from each other.

1014. The three pairs of zinc and platina plates were now opposed by two intervening platina plates, fig. 23. In this case the current was stopped.

1015. Four pairs of zinc and platina plates were also neutralized by two interposed platina plates, fig. 24.

1016. Five pairs of zinc and platina, with two interposed platina plates, fig. 25, gave a feeble current; there was permanent deflexion at the galvanometer, and decomposition in the cells vi and vii. But the current was very feeble; very much less than when all the intermediate plates were removed and the two extreme ones only retained; for when they were placed six inches asunder in one cell, they gave a powerful current. Hence five exciting pairs, with two interposed obstructing plates, do not give a current at all comparable to that of a single unobstructed pair.

1017. I have already said that a *very feeble current* passed when the series included one interposed platina and two pairs of zinc and platina plates (1012.). A similarly feeble current passed in every case, and even when only one exciting pair and four intervening platina plates were used, fig. 26, a current passed which could be detected at x, both by chemical action on the solution of iodide of potassium, and by the galvano-

meter. This current I believe to be due to electricity reduced in intensity below the point requisite for the decomposition of water (970. 984.); for water can conduct electricity of such low intensity by the same kind of power which it possesses in common with metals and charcoal, though it cannot conduct electricity of higher intensity without suffering decomposition, and then opposing a new force consequent thereon. With an electric current under this intensity, it is probable that increasing the number of interposed platina plates would not involve an increased difficulty of conduction.

1018. In order to obtain an idea of the additional interfering power of each added platina plate, six voltaic pairs and four intervening platinas were arranged as in fig. 27; a very feeble current then passed (985. 1017.). When one of the platinas was removed so that three intervened, a current somewhat stronger passed. With two intervening platinas a still stronger current passed: and with only one intervening platina a very fair current was obtained. But the effect of the successive plates, taken in the order of their interposition, was very different, as might be expected; for the first retarded the current more powerfully than the second, and the second more than the third.

1019. In these experiments both amalgamated and unamalgamated zinc were used, but the results generally were the same.

1020. The effects of retardation just described were altered altogether when changes were made in the *nature of the liquid* used between the plates, either in what may be called the *exciting* or the *retarding* cells. Thus, retaining the exciting force the same, by still using pure dilute sulphuric acid for that purpose, if a little nitric acid were added to the liquid in the *retarding* cells, then the transmission of the current was very much facilitated. For instance, in the experiment with one pair of exciting plates and one intervening plate (1011.), fig. 20, when a few drops of nitric acid were added to the contents of cell ii, then the current of electricity passed with considerable strength (though it soon fell from other causes (1036. 1040.),) and the same good effect was produced by the nitric acid when many interposed plates were used.

1021. This seems to be a consequence of the diminution of the difficulty of decomposing water when its hydrogen, as in these cases, instead of being absolutely expelled, is transferred to the oxygen of the nitric acid, producing a secondary result at the *cathode* (752.); for in accordance with the chemical views of the electric current and its action already advanced (913.), the water, instead of opposing a resistance to decom-

position equal to the full amount of the force of mutual attraction between its oxygen and hydrogen, has that force counteracted in part, and therefore diminished by the attraction of the hydrogen at the *cathode* for the oxygen of the nitric acid which surrounds it, and with which it ultimately combines instead of being rendered in its free and independent state.

1022. When a little nitric acid was put into the exciting cells, then again the circumstances favouring the transmission of the current were strengthened, for the *intensity* of the current itself was increased by the addition (906.). When therefore a little nitric acid was added to both the *exciting* and the *retarding* cells, the current of electricity passed with very considerable freedom.

1023. When dilute muriatic acid was used, it produced and transmitted a current more easily than pure dilute sulphuric acid, but could not compete with nitric acid. As muriatic acid appears to decompose more freely than water (765.), and as the affinity of zinc for chlorine is very powerful, it might be expected to produce a current more intense than that from the use of dilute sulphuric acid; and also to transmit it more freely by undergoing decomposition at a lower intensity (912.).

1024. In relation to the effect of these interpositions, it is necessary to state that they do not appear to be at all dependent upon the size of the electrodes, or their distance from each other in the acid, except that when a current *can pass*, changes in these facilitate or retard its passage. For on repeating the experiment with one intervening and one pair of exciting plates (1011.), fig. 20, and in place of the interposed plate P using sometimes a mere wire, and sometimes very large plates (1008.), and also changing the terminal exciting plates Z and P, so that they were sometimes wires only and at others of great size, still the results were the same as those already obtained.

1025. In illustration of the effect of distance, an experiment like that described with two exciting pairs and one intervening plate (1012.), fig. 21, was arranged so that the distance between the plates in the third cell could be increased to six or eight inches, or diminished to the thickness of a piece of intervening bibulous paper. Still the result was the same in both cases, the effect being no greater, sensibly, when the plates were merely separated by the paper, than when a great way apart; so that the principal opposition to the current does not depend upon the *quantity* of intervening electrolytic conductor, but on the *relation of its elements to the*

intensity of the current, or to the chemical nature of the electrodes and the surrounding fluids.

1026. When the acid was sulphuric acid, *increasing its strength* in any of the cells, caused no change in the effects; it did not produce a more intense current in the exciting cells (908.), or cause the current produced to traverse the decomposing cells more freely. But if to very weak sulphuric acid a few drops of nitric acid were added, then either one or other of those effects could be produced; and, as might be expected in a case like this, where the exciting or conducting action bore a *direct* reference to the acid itself, increasing the strength of this (the nitric acid), also increased its powers.

1027. The *nature of the interposed plate* was now varied to show its relation to the phænomena either of excitation or retardation, and amalgamated zinc was first substituted for platina. On employing one voltaic pair and one interposed zinc plate, fig. 28, there was as powerful a current, apparently, as if the interposed zinc plate was away. Hydrogen was evolved against P in cell ii, and against the side of the second zinc in cell i; but no gas appeared against the side of the zinc in cell ii, nor against the zinc in cell i.

1028. On interposing two amalgamated zinc plates, fig. 29, instead of one, there was still a powerful current, but interference had taken place. On using three intermediate zinc plates, fig. 30, there was still further retardation, though a good current of electricity passed.

1029. Considering the retardation as due to the inaction of the amalgamated zinc upon the dilute acid, in consequence of the slight though general effect of diminished chemical power produced by the mercury on the surface, and viewing this inaction as the circumstance which rendered it necessary that each plate should have its tendency to decompose water assisted slightly by the electric current, it was expected that plates of the metal in the unamalgamated state would probably not require such assistance, and would offer no sensible impediment to the passing of the current. This expectation was fully realized in the use of two and three interposed unamalgamated plates. The electric current passed through them as freely as if there had been no such plates in the way. They offered no obstacle, because they could decompose water without the current; and the latter had only to give direction to a part of the forces, which would have been active whether it had passed or not.

1030. Interposed plates of copper were then employed. These seemed at first to occasion no obstruction, but after a

few minutes the current almost entirely ceased. This effect appears due to the surfaces taking up that peculiar condition (1040.) by which they tend to produce a reverse current; for when one or more of the plates were turned round, which could easily be effected with the *couronne des tasses* form of experiment, fig. 18, then the current was powerfully renewed for a few moments, and then again ceased. Plates of platina and copper, arranged as a voltaic pile with dilute sulphuric acid, could not form a voltaic trough competent to act for more than a few minutes, because of this peculiar counteracting effect.

1031. All these effects of retardation, exhibited by decomposition against surfaces for which the evolved elements have more or less affinity, or are altogether deficient in attraction, show generally, though beautifully, the chemical relations and source of the current, and also the balanced state of the affinities at the places of excitation and decomposition. In this way they add to the mass of evidence in favour of the identity of the two; for they demonstrate, as it were, the antagonism of the *chemical powers* at the electromotive part with the *chemical powers* at the interposed parts; they show that the first are *producing* electric effects, and the second *opposing* them; they bring the two into direct relation; they prove that either can determine the other, thus making what appears to be cause and effect convertible, and thereby demonstrating that both chemical and electrical action are merely two exhibitions of one single agent or power (916. &c.).

1032. It is quite evident that as water and other electrolytes can conduct electricity without suffering decomposition (986.), when the electricity is of sufficiently low intensity, it may not be asserted as absolutely true in all cases, that whenever electricity passes through an electrolyte, it produces a definite effect of decomposition. But the quantity of electricity which can pass in a given time through an electrolyte without causing decomposition, is so small as to bear no comparison to that required in a case of very moderate decomposition: and with electricity above the intensity required for decomposition, I have found no sensible departure as yet from the law of *definite electrolytic action* developed in the preceding series of these Researches (783. &c.).

1033. I cannot dismiss this division of the present paper without making a reference to the important experiments of M. Aug. De la Rive on the effects of interposed plates*. As I have had occasion to consider such plates merely as giving

* *Annales de Chimie* [*et de Physique*], tom. xxviii. p. 190; and *Mémoires de Génève*.

rise to new decompositions, and in that way only, causing obstruction to the passage of the electric current, I was freed from the necessity of considering the peculiar effects described by that philosopher. I was the more willing to avoid for the present touching upon these, as I must at the same time have entered into the views of Sir Humphry Davy upon the same subject*, and also those of Marianini † and Ritter ‡, which are connected with it.

[To be concluded in the next number.]

LVII. *On the Summation of slowly converging and diverging Infinite Series.* By J. R. Young, *Professor of Mathematics in Belfast College.*

COMMODIOUS methods for approximating to the sum of a slowly converging infinite series are very valuable in many departments of physical science. Philosophical inquiries of the highest interest and importance frequently terminate in series of this kind, which would be practically useless, on account of the impossibility of the actual summation, did we not possess the means of transforming them to others of such rapid convergency that the sum of a moderate number of the leading terms may in each case afford a near approximation to that of the entire series. Of all such methods of transformation that furnished by the well-known *Differential Theorem* is, perhaps, the most extensively applicable; and it is, therefore, in one form or other, generally employed for this purpose. In the application, however, of this theorem, as well as in that of all other practical formulæ intended to abridge numerical labour, there is room for the exercise of some ingenuity as to the most advantageous arrangement of the arithmetical process; for if this arrangement be not such as to render the amount of calculation by the proposed formulæ a minimum, it is plain that we do not derive from that formula all the advantage, as a facilitating principle, which it is capable of affording.

In the present paper it is my wish, first to give a short and easy investigation of the differential theorem, and, by deducing it in a somewhat more complete form than that in which it usually appears, to show that it is capable of furnishing, not only a near approximation, but also very close superior and inferior limits, to the sum of a slowly converging or diverging

* Philosophical Transactions, 1826, p. 413. [or Phil. Mag. and Annals, N.S., vol. i. p. 193.—Edit.]

† *Annales de Chimie* [*et de Physique*], tom. xxxiii. pp. 117, 119, &c.

‡ *Journal de Physique*, tom. lvii. pp. 349, 350.

series; and lastly, to exhibit its numerical application in a more commodious form than any in which I have yet seen it.

Let $$a - bx + cx^2 - dx^3 + \&c. = S$$
$$\therefore\ -bx + cx^2 - dx^3 + \&c. = S - a$$
$$-b + cx - dx^2 + ex^3 - \&c. = \frac{S-a}{x}$$
$$\therefore\ -b - \Delta x + \Delta' x^2 - \Delta'' x^3 + \&c. = \frac{x+1}{x}(S-a)$$
$$\therefore\ -bx - \Delta x^2 + \Delta' x^3 - \Delta'' x^4 + \&c. = (x+1)(S-a) = S''$$
$$\therefore\ S = \frac{S'}{x+1} + a;$$

that is,

$$S = a - \frac{bx}{x+1} - \frac{\Delta x^2}{x+1} + \frac{\Delta' x^3}{x+1} - \frac{\Delta'' x^4}{x+1} + \&c.$$
$$= a - \frac{bx}{x+1} + \frac{x}{x+1}\left\{0 - \Delta x + \Delta' x^2 - \Delta'' x^3 + \&c.\right\}$$

Hence, treating the series within the brackets as we have treated the original, to which it is similar in form, we have

$$S = a - \frac{bx}{x+1} - \frac{\Delta x^2}{(x+1)^2} - \frac{\Delta^2 x^3}{(x+1)^3} + \frac{\Delta^{2'} x^4}{(x+1)^3} - \frac{\Delta^{2''} x^5}{(x+1)^3} + \&c.$$

Similarly,

$$S = a - \frac{bx}{x+1} - \frac{\Delta x^2}{(x+1)^2} - \frac{\Delta^2 x^3}{(x+1)^3} - \frac{\Delta^3 x^4}{(x+1)^3} + \frac{\Delta^{3'} x^5}{(x+1)^3} - \&c.$$
$$\vdots$$
$$S = a - \frac{bx}{x+1} - \frac{\Delta x^2}{(x+1)^2} - \frac{\Delta^2 x^3}{(x+1)^3} \cdots\cdots - \frac{\Delta^n x^{n+1}}{(x+1)^{n+1}}$$
$$- \frac{\Delta^{n+1} x^{n+2}}{(x+1)^{n+1}} + \&c. \qquad \text{(A.)}$$

These several expressions for S may be regarded as so many differential theorems, but the last is that which corresponds most nearly to the form usually given: it is, however, more efficient, as it shows that if we stop at the term

$$\frac{\Delta^n x^{n+1}}{(x+1)^{n+1}},$$

we get one limit to the sum S, and if we stop at the immediately following term

$$\frac{\Delta^{n+1} x^{n+2}}{(x+1)^{n+1}},$$

we get another limit, in the contrary sense. These limits, as

we shall presently see, may be easily narrowed. By considering the series to terminate at the former of the above terms, it will be the same as that investigated by the late Mr. Baron Maseres, in his *Scriptores Logarithmici*, vol. iii. p. 219, and which the Baron considered to be different from that deduced by Simpson, from a formula still more general, in his Mathematical Dissertations, p. 62. The two forms are, however, mutually interchangeable, regard being paid to the signs of the differences.

Suppose in the series S that $a = 0$; then, dividing both sides of (A.) by $-x$, we shall have

$$S = b - cx + dx^2 - ex^3 + \&c. =$$

$$\frac{b}{x+1} + \frac{\Delta x}{(x+1)^2} + \frac{\Delta^2 x^2}{(x+1)^3} \ldots\ldots + \frac{\Delta^n x^n}{(x+1)^{n+1}} + \frac{\Delta^{n+1} x^{n+1}}{(x+1)^{n+1}} - \&c. \ldots\ldots\ldots\ldots \quad (B.)$$

which when $x = 1$ becomes

$$S = b - c + d - e + \&c. =$$

$$\frac{b}{2} + \frac{\Delta}{4} + \frac{\Delta^2}{8} \ldots\ldots + \frac{\Delta^n}{2^{n+1}} + \frac{\Delta^{n+1}}{2^{n+1}} - \&c. \ldots \quad (C.)$$

This series, supposing it to terminate at $\frac{\Delta^n}{2^{n+1}}$, furnishes the method proposed by Dr. Hutton (Mathemat. Tracts, vol. i. p. 176). In Dr. Hutton's process the value of S is approached by determining in succession the values of

$$\frac{b}{2}, \ \frac{b}{2} + \frac{\Delta}{4}, \ \frac{b}{2} + \frac{\Delta}{4} + \frac{\Delta^2}{8}, \ \&c.,$$

which is done by finding first the successive sums of a few of the leading terms in the proposed series, taking the arithmetical means between each pair of consecutive results, then the means between each pair of these means, and so on. But simple as this operation undoubtedly is, yet, when the numbers consist of several places of figures, it cannot safely be performed mentally; so that Dr. Hutton's numerical examples, which exhibit only the results of these operations, do not fairly present the whole amount of numerical labour. Still his method is, upon the whole, more easy and convenient than any which I have elsewhere seen, although, like all the other methods, it leaves us in doubt about the accuracy of the final decimal or two in the results determined by it, as indeed, every process of approximation must do which does not furnish limits both above and below the value sought.

In the series above marked (B.) it is plain that if we stop at the term involving Δ^n, we shall obtain an inferior limit to the sum S, and if we take in the term immediately following we shall get a superior limit.

Now, to narrow these limits, we must observe, that since

$$\Delta^{n+1} = \Delta^n - \Delta^{n\prime},$$

a superior limit will be obtained by adding to the inferior limit the quantity

$$\frac{\Delta^n x^{n+1}}{(x+1)^{n+1}}.$$

Moreover, the inferior limit cannot differ from the entire sum by so much as

$$\frac{\Delta^{n+1} x^{n+1}}{(x+1)^{n+1}},$$

whereas the superior limit differs from the truth by more than

$$\frac{\Delta^{n\prime} x^{n+1}}{(x+1)^{n+1}},$$

in as much as the succeeding term in the series (B.) is also negative. The inferior limit will therefore be nearer to the truth than the superior, since $\Delta^{n\prime} > \Delta^{n+1}$ and, consequently, half the sum of the two limits will be a superior limit still nearer. We may conclude, therefore, that if we multiply the final term in the inferior limit by $\frac{x}{2}$, and add the product to that limit, we shall thus obtain a near superior limit.

It is scarcely necessary to observe here, that in what has been hitherto said, the coefficients in the proposed series S are supposed continually to diminish, as also the several series of differences, which supposition is conformable to what usually occurs in practice when S is convergent. When the series is divergent, the formula (B.) or (A.) is still applicable, regard being paid to the signs of the differences.

1. As a first example, let there be proposed the slowly converging series

$$1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \frac{1}{9} - \frac{1}{11} + \&c.,$$

which expresses the length of the quadrantal arc of a circle whose diameter is 1. It will be advisable to actually sum up a few of the leading terms, and to apply the formula (B.), or rather (C.), to the remaining part. The work may be arranged as follows:

$$\begin{array}{l|l}
+1 & \\
-\ \cdot 3 & \\
+\ \cdot 2 & \\
-\ \cdot 142857 & \\
+\ \cdot 111111 & \\
-\ \cdot 090909 & \cdot 744012 = \text{sum of first six terms.} \\
\hline
+\ \cdot 076923 & 10256 \\
-\ \cdot 066667 & 7844 \\
+\ \cdot 058823 & 6191 \\
-\ \cdot 052632 & 5013 \\
+\ \cdot 047619 &
\end{array}
\quad
\begin{array}{r|r|r}
2412 & 759 & 284 \\
1653 & 475 & \\
1178 & &
\end{array}$$

The numbers ·076923, 10256, 2412, and 284 are the respective values of b, Δ, Δ^2, Δ^3, and Δ^4 in (C.), and to deduce from these the value of S, it will be necessary merely to add half the last number 284 to the preceding, half the sum to the next, and so on, to the last, adding half the final sum to the number ·744012 previously found. The remainder of the operation, therefore, is as follows:

$$\begin{array}{lllll}
\cdot 076923 & 10256 & 2412 & 759 & 284 \\
\cdot 082767 & 11688 & 2864 & 901 & 142 \\
\cdot 041384 & 5844 & 1432 & 452 & \\
\cdot 744012 & & & & \\
\hline
\cdot 785396 & = \text{inferior limit.} & & & \\
4 & = \dfrac{142}{2^5} & & & \\
\hline
\cdot 785400 & = \text{superior limit.} & & &
\end{array}$$

$$\therefore\ \cdot 785398 = \frac{\pi}{4} \text{ very nearly.}$$

This value of $\frac{\pi}{4}$ we know from the small interval between the limits cannot possibly differ from the truth by more than a unit in the final decimal. It is, in fact, true even in the last decimal. We have separated the two parts of the process in this example for the purpose of clearer illustration; but they may be combined as in the following.

2. To find the value of the converging series

$$1 - \frac{1}{2^2} + \frac{3^2}{2^2.4^2} - \frac{3^2.5^2}{2^2.4^2.6^2} + \frac{3^2.5^2.7^2}{2^2.4^2.6^2.8^2} - \&c.,$$

which occurs in the expression for the time of vibration of a pendulum in a circular arc,

+1
− ·25
+ ·140625
− 97656
+ 74768
− 60562 | ·807175 = sum of first six terms.

+ 50889	7010	1696		
− 43879	5314	1148	548	212
+ 38565	4166	812	336	
− 34399	3354	2023	654	106
+ 31045	8022	1012	327	
54900	4011			
27450				
·807175				

·834625 = inferior limit.

$$3 = \frac{106}{2^5}$$

834628 = superior limit.
∴ 834626 = S very nearly.

A value which cannot differ from the truth by more than a unit in the last decimal. It is, in fact, true in all its places.

3. Let it be required to find the value of the diverging series
$$\frac{1}{2} - \frac{2}{3} + \frac{3}{4} - \frac{4}{5} + \&c.$$

+ ·5
− ·666666
+ ·75
− ·8
+ ·833333
− ·857143 | − ·240476 = sum of first six terms.

+ 875000	−13889	−2778		
− 888889	11111	2020	−758	−253
+ 9	09091	1515	505	
− 909091	07576	3220	884	126
+ 916667	14499	1610	442	
867251	7749			
433625				
−240476				

·193149 = superior limit.

$$4 = \frac{126}{2^5}$$

·193145 = inferior limit. Hence ·193147 = S very nearly, which is true in the last decimal.

4. As a last example let the series

$$1 - 2 + 4 - 8 + \&c.$$

be proposed. Then, comparing with the formula (B.), we have $x = 2$ and b, c, &c. each $= 1$,

$$\therefore S = \frac{b}{x+1} = \frac{1}{3}.$$

In a similar way may the sum of $1-4+9-16$ be readily found.

March 9, 1835. J. R. Young.

[To be continued.]

LVIII. *Experiments on the Action of Metals in determining Gaseous Combination.* *By* William Charles Henry, *M.D., F.R.S.**

The property, first discovered by Döbereiner † in spongy platina of inducing gaseous union, has been recently shown by Dr. Faraday ‡ to exist also in compact plates of that metal, as well as in plates of palladium and of gold, and hence to be independent of fineness of division or porosity of structure. This important result, while it demonstrated the inadequacy of all theories of the action of platina that had been before proposed, suggested to Dr. Faraday the idea, that gaseous combination, thus induced, may be due partly to the statical relations subsisting between elastic fluids and the solid surfaces by which they are bounded, and partly to an attractive force, exerted at insensible distances, and probably belonging to all bodies. By the joint influence of these two conditions, the gases, he imagines, are so far condensed on the metallic surface "as to be brought within the action of their mutual affinities at the existing temperature." This ingenious theory, though mainly resting on the fact that perfect purity from foreign matter is the only condition in the metallic surface essential to its activity, is further supported by an extensive induction of analogous actions.

Receiving the theory of Dr. Faraday, in so far as it has been developed by him, as correctly representing the nature of these phænomena, it still remains to assign a cause for the

* Read before the Literary and Philosophical Society of Manchester; and communicated by the Author.

† [An account of Prof. Döbereiner's experiments, and of those of other chemists, on the same subject, will be found in Phil. Mag. (First Series), vol. lxii. p. 282—292: see also vol. lxiii. p. 71, and vol. lxiv. p. 3.—Edit.]

‡ [An abstract of Mr. Faraday's Sixth Series of Experimental Researches in Electricity, containing his observations on this subject, was given in Lond. and Edinb. Phil. Mag., vol. iv. p. 291.—Edit.]

marked preeminence of platina, and of a few metals closely allied to it in chemical properties, over all other metals and solid bodies that have been the subjects of experiment. Thus platina has been shown to induce gaseous union at so low a temperature as $-4°$ Fahrenheit*, and palladium and gold in the form of plates, and rhodium and iridium in the state of powder, at atmospheric temperatures. All other metals and solids are entirely inert at the temperature of the atmosphere, and, with the exception of silver and osmium, require, in order to effectuate gaseous union, to be heated nearly to the boiling point of mercury. Now the statical condition of the film of gaseous matter contiguous to the metallic superficies (one of the causes assigned by Dr. Faraday of greater density in that portion of the gaseous mixture) being quite independent of the nature of the bounding solid, must cause an equal degree of condensation upon all the metals, and, indeed, upon all continuous surfaces. The attractive force (the other postulate in Dr. Faraday's theory) may be supposed to be of variable amount in different solid bodies. But no experimental proof has yet been given that platina possesses a stronger attraction than the other metals for gaseous fluids; on the contrary, the experiments of Magnus† have shown that iron, nickel, and cobalt absorb or condense the different gases to a large amount.

The following experiments (in several of which I was indebted for valuable assistance to my friend Mr. Joseph Ransome,) were designed to investigate the cause of the inferiority of the other metals to platina in determining the union of hydrogen and oxygen. Since these actions, whatever be their essential character, manifestly reside on surfaces, it seemed probable that by employing the metals in that state in which they present the largest amount of superficial extension, and by thus augmenting the energy of the operating forces, their true nature might be unfolded. Mechanical processes seemed inadequate to ensure an absolutely untarnished surface; and the chemical agents, employed with success by Dr. Faraday, for cleansing the surface of platina, were obviously inapplicable to the oxidizable metals. The most promising mode of obtaining this class of metals in the requisite state of purity and mechanical division appeared to consist in precipitating them from their salts in the condition of oxides, and in reducing those oxides by heating them in hydrogen gas.

Several preliminary experiments showed that bright copper turnings, zinc-foil, iron turnings, box-wood charcoal recently

* Delarive and Marcet, *Ann. de Chim. et de Phys.*, tom. xxxix. p. 328.
† *Ann. de Chim. et de Phys.*, tom. xxx. p. 103.

ignited and cooled under mercury, and pounded glass washed in hot alkali and acid and then repeatedly in distilled water, when introduced into curved tubes containing oxygen and hydrogen in the proportions constituting water, did not induce the silent union of the gases, until the tubes were heated to near the boiling-point of mercury. All these substances acted nearly at the same temperature.

§ I. *Copper.*

1. Oxide of copper, obtained by calcination of the nitrate, was exposed in a green glass tube to a current of hydrogen, issuing from dilute sulphuric acid and zinc. The temperature was gradually raised by a spirit-lamp to a low red heat, when the process of reduction commenced, and the bright incandescence, described by Berzelius, was observed to spread along the powder, in the line of reduction, even after the lamp had been withdrawn. The metallic copper thus obtained was light and spongy, and underwent no change in the atmosphere at ordinary temperatures.

2. A portion of this copper, exposed to the air in an open capsule, was heated on a sand-bath to upwards of 500° Fahrenheit, and a stream of hydrogen made to flow constantly over its surface. The gas was not inflamed, but the metal itself became rapidly tarnished, and was finally reconverted into black oxide. Precisely the same change was effected by simply heating the metal without the presence of hydrogen.

3. Oxide of copper, thrown down from the sulphate by caustic potassa, and sufficiently washed with distilled water, was reduced in the same manner. A jet of hydrogen was directed upon the pure and porous copper so obtained, which was then slowly heated on a platina dish by a spirit-lamp. As in the last experiment, it speedily began to lose the metallic aspect, and was reconverted into black oxide. The heat was increased to near redness, when the powder suddenly became incandescent, and though the lamp was withdrawn, continued to glow brightly as long as the current of hydrogen was supplied. In appearance the incandescence was identical with that of powdered platina or rhodium under like circumstances.

Copper, then, in a state of fine mechanical division, does not, like platina, *directly* induce the union of hydrogen with oxygen at any temperature. At all temperatures below that at which its oxide is reducible, the affinity of copper for oxygen surpasses the affinity of hydrogen for oxygen. Hence when heated in the open air, either with or without the presence of hydrogen gas, the copper absorbs oxygen, and is finally converted into the state of black oxide, hydrogen, if present,

escaping unburned. These actions are exhibited in the first experiment. But if the heat be raised to the degree at which oxide of copper is reducible by hydrogen gas, the newly-formed oxide yields its oxygen to hydrogen in the open air just as in a closed tube, and becomes, as in the latter case, incandescent. The continuance of the glow, after removing the lamp, is due to a succession of alternate reductions and reoxidations; for the metal, at the moment of reduction, being at the temperature at which it can unite with the oxygen of the air, is reconverted into oxide, which is again reduced by the hydrogen; the necessary temperature of the mass being sustained by other contiguous portions in the state of incandescence. It is therefore not metallic copper, but oxide of copper, which induces the combustion of the hydrogen, and the silent formation of water. In further proof of this mode of action, it may be added, that *oxide of copper* from the nitrate, exposed on a platina dish to a current of hydrogen with free access of air, and gradually heated to below visible redness, became incandescent, and continued to glow as long as a stream of hydrogen was directed upon it.

§ II. *Lead.*

Hydrate of lead thrown down by potassa from the acetate, was heated in a glass tube, in contact with hydrogen gas, until it was converted into a dark grey powder. This powder was heated in the open air, and a stream of hydrogen was directed upon its surface. It was notwithstanding converted into protoxide, sometimes with, sometimes without, faint incandescence. On increasing the heat, the surface of the oxide upon which the hydrogen impinged was again reduced, while the remoter portions became pink and passed slowly into a higher degree of oxidation.

Since, then, recently reduced copper and lead, though ranking among metals endowed with feeble affinities for oxygen, exert a stronger affinity than hydrogen gas for that element, it might be anticipated that the more oxidizable metals, and especially such as are capable of decomposing water, would *à fortiori* fail to induce direct gaseous union.

§ III. *Cobalt.*

1. Oxalate of cobalt obtained from zaffre (by Dr. Thomson's process) was heated in a glass retort, without access of air, till carbonic acid gas ceased to be evolved, and the metallic cobalt was left in the form of a black powder. The cobalt obtained by this process was not pyrophoric, nor did it inflame a jet of hydrogen directed upon it at the existing temperature. When heated to considerably below visible red-

ness, the powder became incandescent and was converted into an oxide. A stream of hydrogen directed upon it in this state supported the incandescence for an unlimited period, without the aid of external heat.

2. Protoxide of cobalt was reduced in a tube by hydrogen at a low red heat, without exhibiting incandescence. During reduction the colour of the powder changed from black to ash-grey. Small portions of the reduced metal, when scattered on paper, ignited spontaneously, as in the experiment of Magnus, and inflamed the paper. The rest of the powder was quickly transferred from the reducing tube to a platina dish, upon which a current of hydrogen had been previously directed. The metal instantly became incandescent, and continued to glow as long as hydrogen gas issued in sufficient abundance. No external heat was employed. The substance left at the conclusion of the experiment was in all respects analogous to the original protoxide, except that its colour was of a deeper black.

Cobalt, then, like the less oxidizable metals, is destitute of the property of inducing the union of hydrogen with free oxygen. Its action is the same as that of copper, except that the incandescence takes place during the stage of oxidation, not during that of reduction.

§ IV. *Nickel.*

1. Nitrate of nickel was heated to redness in a porcelain crucible till nitrous fumes ceased to be disengaged. The ash-gray protoxide thus obtained was reduced in a glass tube by hydrogen. During reduction, the colour changed to a brownish black, but the powder did not become incandescent. The metallic nickel was not pyrophoric, nor did it act upon a jet of hydrogen at the temperature of the atmosphere. When slowly heated on a platina tray, the hydrogen continuing to flow over its surface, it became incandescent, and was maintained in that state till the current of hydrogen ceased. The portion of powder contiguous to the orifice from which the hydrogen issued, was distinguished from the remoter parts by a marked difference of colour. That upon which the hydrogen was acting, was of lighter colour than the original protoxide. The powder most distant from the jet was of darker gray, and when heated, without contact with hydrogen, glowed for a moment, and assumed the same tint as the part that had been kept incandescent.

2. A second portion of the metallic nickel was simply heated out of contact with hydrogen gas: it became incandescent, but speedily ceased to glow, being reconverted into oxide.

3. Finally, protoxide of nickel was heated in an open dish,

upon which a stream of hydrogen was flowing. It became incandescent considerably below visible redness, and continued so as long as hydrogen was supplied.

The action of nickel differs, then, in no respect from that of cobalt, but consists in a similar succession of oxidations and reductions. It is therefore entirely distinct from that of platina and its congenera* ; yet nickel has been placed by Döbereiner, MM. Dulong and Thenard, and Mitscherlich †, all of whom observed its activity in the form of sponge, in the same category with platina and the noble metals.

§ V. *Iron.*

1. The yellow oxalate of iron was heated in a closed retort until carbonic acid was no longer liberated. The reduced metal was pyrophoric when poured through the air. A portion, carefully transferred from the retort to a platina dish, on which a current of hydrogen was flowing, became incandescent without foreign heat; and a circular ring of powder nearest the aperture from which the gas issued, continued to glow as long as hydrogen was produced. The oxide immediately contiguous to this ignited circle was black, but the remoter parts had passed into the state of red oxide and underwent no further change. The incandescence continued for many minutes, and at length became so vivid as to kindle the jet of hydrogen‡.

After the experiment had terminated and the product been allowed to cool, it appeared that the metal was entirely converted into the state of oxide, and chiefly of red oxide. This oxide was heated on a platina dish, and a stream of hydrogen directed upon it. About the temperature of reduction it became incandescent at the points of its surface where the hydrogen impinged, and after the lapse of a few minutes inflamed the hydrogen.

It appears, then, that iron, when recently reduced and in a pulverulent state, does not induce the direct combination of hydrogen with oxygen. Like the other oxidizable metals before enumerated, it causes the silent formation of water, only

* " .... celle de faciliter par leur contact la combinaison des fluides élastiques sans s'unir à aucun de ces fluides ou de leurs composés."—*Thenard*, tom. ii. p. 19. 6^me^ Edit.

† *Lehrbuch der Chemie*, b. i. p. 226.

‡ This experiment, as well as the second on cobalt, are liable to objection from the pyrophoric state of the metals, and are only introduced as completing the series. Stromeyer has also called in question the perfect reducibility of oxide of iron by hydrogen, and is of opinion that the pyrophoric substance is the protoxide, and not the pure metal.

at the temperature of reduction. It then alternately absorbs the oxygen of the air and yields it to the hydrogen, in the same mode as a given portion of nitrous gas has been supposed to act in repeatedly carrying the atmospheric oxygen to sulphurous acid in the process of making oil of vitriol.

§ VI. *Silver.*

As a contrast to the results of the foregoing experiments, oxide of silver, obtained from the nitrate by caustic potassa, was heated on a platina dish, in the open air, and a current of hydrogen made to flow upon it. The oxide was instantly reduced, and the pure metal underwent no further change, but, when strongly heated, inflamed a jet of hydrogen, without itself becoming incandescent.

The property of inducing the union of hydrogen with oxygen, *at common temperatures*, had been ascribed by former inquirers to nickel as well as to the noble metals. It must now be restricted to the section of metals which are characterized "as incapable of absorbing oxygen or decomposing water at any temperature, and whose oxides are reducible below a red heat." The foregoing experiments further demonstrate that the oxidizable metals, when so minutely divided as to be in great measure freed from the control of cohesive attraction, and at liberty to obey their natural affinities, do not *at any temperature* determine the *direct* union of hydrogen with free oxygen; their own more energetic affinity for oxygen predominating over the weaker affinity of hydrogen for oxygen, and inducing the oxidation of metal in preference to the formation of water. When raised to a low red heat, in contact with hydrogen, and with access of air, the *oxides* of these metals have been further shown to cause the combustion of hydrogen, by yielding their oxygen to that element, and instantly recombining with fresh atmospheric oxygen. The continued incandescence thus exhibited, though apparently identical with that of platina, has been traced to a series of alternate reductions and reoxidations.

When in a state of more compact aggregation, these metals, it is true, effectuate gaseous combination, but only at a temperature approaching that of boiling mercury*. In this state

* It may be doubted whether, even in the compact state, the oxidizable metals permit the union of hydrogen with oxygen, until their own surfaces have combined with oxygen. For the metallic foil and turnings, which were pure and bright when introduced into the mixed gases, were found to be tarnished and covered with a film of oxide when withdrawn, after having induced gaseous union.

the force of cohesion restrains the affinity of the metal for oxygen, and thus enables the hydrogen to exert, at a temperature of about 650° Fahrenheit, that stronger attraction for oxygen which, when directed upon a *finely divided* metal or oxide, it does not manifest below an incipient red heat.

Finally, it appears probable that the particles of oxygen and hydrogen are brought within their combining distances on the surface of iron or copper as well as on that of platina, but that on the oxidizable metals their combination is prevented by the stronger affinity of the contiguous atoms of metal for oxygen.

Another argument, in favour of the view which has been taken, is the inactivity of platina itself, noticed by Dr. Faraday, when introduced into mixtures of hydrogen and chlorine, gases which are so much more readily combinable by other means than hydrogen and oxygen. This inactivity is most probably due to an interfering affinity of platina for chlorine, —an electro-negative which manifests far more energetic affinities for the metals than oxygen exerts, and is indeed, the only solvent of gold and platina, when presented to them, in its nascent state, in aqua regia.

The power which certain gases exercise of suspending or wholly preventing the action of platina on mixtures of hydrogen and oxygen, was several years ago ascribed to the similar interference of an opposing affinity. (Dr. Henry on the Action of Spongy Platina on Gaseous Mixtures, in the Philosophical Transactions for 1824*.) In that essay it was shown that the only gases possessing this singular property are such as are capable, under the influence of platina, of combining with oxygen, either at atmospheric or at moderately elevated temperatures. Thus, carbonic oxide—which, when added in the proportion of half a volume to one volume of a mixture of hydrogen and oxygen, prevented the action of the sponge,—is known to combine slowly with oxygen in presence of the sponge at ordinary temperatures, and rapidly at a heat between 300° and 340° Fahrenheit. It is there, also, proved that the affinity of carbonic oxide for oxygen greatly surpasses that of hydrogen for oxygen within a considerable range of temperature. "When carbonic oxide and hydrogen gases in equal volumes, mixed with oxygen sufficient to saturate only one of them, were heated in contact with the sponge to 340°, four fifths of the oxygen united with the carbonic oxide, and only one fifth with the hydrogen." A similar relation between the

* [Dr. Henry's paper will be found also in Phil. Mag. (First Series), vol. lxv. p. 269.—Edit.]

affinities of carbonic oxide and hydrogen for oxygen was observed in their slow combination at atmospheric temperatures. "The oxygen which had united with the carbonic oxide was to that which had combined with the hydrogen as about 5 to 1 in volume."

From the foregoing facts it may be inferred that when either carbonic oxide or hydrogen gas is condensed with oxygen on the surface of platina, it is brought within the range of its combining affinity, and unites with oxygen, the latter rapidly, the former with such extreme slowness as to give evidence of the production of carbonic acid only after the lapse of a day or two. When the two gases are simultaneously condensed with oxygen sufficient to saturate only one of them, the stronger affinity of carbonic oxide for oxygen prevails over the weaker affinity of hydrogen for oxygen, and induces the formation of carbonic acid, but so tardily as to exhibit no immediate action, and hence to give occasion to the phænomena of *interference*. The retarding influence of foreign gases may, then, like the non-action of the oxidizable metals, be traced to the operation of a countervailing affinity.

The insufficiency of most of the hypotheses previously framed to explain this class of phænomena has been fully exposed by Dr. Faraday. There is one, however, which deserves to be noticed, since, though adopted by some of the most eminent German chemists, it appears to have escaped his observation. Proposed by Döbereiner in Schweigger's Journal, it seems to have reached the *Annales de Chimie* only through a memoir of Liebig*. Platina in the form of powder is asserted by Döbereiner to absorb many volumes of the *unmingled* gases, and especially of pure hydrogen. Thus, 100 grains absorbed 20 cubic inches of hydrogen, or in volume 1 cubic inch of powder absorbed 745 cubic inches of the gas. A small part of this (5 cubic inches) is supposed to have been employed in the formation of water, and the remaining 15 cubic inches to have been simply condensed by the powder, by an action resembling, but greatly exceeding in amount, that of charcoal. The heat evolved by this enormous condensation is calculated to be fully adequate to render the metal in-

* tom. xlii. p. 316. [We cannot at present refer to Schweigger, but the passage in the *Annales* just cited, relates merely to the black precipitate obtained by Mr. E. Davy by heating sulphate of oxide of platinum with alcohol, and not to platinum powder. This, in conjunction with the statement mentioned in our note on the succeeding page, seems to indicate the existence of some error in the history of the subject as stated above. Perhaps Dr. C. Henry will have the goodness to reconcile the apparent contradiction in our next Number.—Edit.]

candescent, and to inflame the gas, if oxygen be present. Mitscherlich also regards the action of charcoal, in causing the rapid union of sulphuretted hydrogen and oxygen, as identical in character with that of platina on other gaseous mixtures*. Other experimenters have stated, on the contrary, that platina exerts no appreciable action on pure hydrogen or pure oxygen, and have sought the theory of its operation in the phænomena of its contact with those gases in a state of mixture†. It appeared, therefore, important to contrast by fresh observations the action of platina with that of charcoal upon the simple gases.

In these experiments I employed box-wood charcoal, which was heated to redness and cooled under mercury before admission into the gases. The results constituted a series of numbers very nearly accordant with those of Saussure, with the single exception of sulphuretted hydrogen, which was absorbed in larger proportion than is stated by that experimenter. One volume of charcoal, I found, absorbed eighty-one volumes of sulphuretted hydrogen. The absorption was always effected with far greater rapidity during the first moments of contact with all the gases than afterwards.

Platina, in the form of sponge and of clay balls, was similarly introduced into tubes containing the separate gases over mercury. No immediate diminution of volume could ever be detected; and in most trials, the space occupied by the gas was increased by a quantity equivalent to the volume of the platina sponge or ball. In some cases, when the sponge was left for a day or two in contact with the gas, there was an appreciable, though very slight absorption. Thus, a small piece of sponge passed into 5 cubic inches of hydrogen did not by its own bulk augment the volume of the gas, and after the lapse of two days had absorbed about $\frac{1}{4}$ cubic inch. In not one of the many experiments in which platina was introduced into pure oxygen gas, and allowed to remain for several days, was there any appreciable absorption. Even ammoniacal, muriatic acid and sulphuretted hydrogen gases, which are so largely and rapidly condensed by charcoal, underwent no immediate change of volume from exposure to spongy platina,

* *Lehrbuch der Chemie*, b. i. p. 226 and 394.

† Marcet and Delarive, *Ann. de Chim. et de Phys.*, tom. xxxix.; and Dr. Faraday (567). [It is remarkable that this statement had been originally made also by Döbereiner, as appears from a paper by Dr. Schweigger, in the Journal bearing his name, of which a translation was given in Phil. Mag., vol. lxiv. p. 3. Schweigger quotes Döbereiner as saying that "the hydrogen is neither absorbed nor condensed by the metallic platinum dust, and in the recital of his experiments, that "No condensation of hydrogen occurred when I placed it in contact with platinum dust," and certain other substances which he mentions.—Edit.]

and were but slightly affected by prolonged contact with it. Since obtaining these results, I have observed that Thenard had previously given the same testimony*.

The almost total absence of the power of absorbing gaseous matter in spongy platina, indicated by these experiments, is irreconcileable with the properties attributed to the black powder of Liebig, which is regarded by him as nothing more than pure metallic platina in a state of extreme subdivision.

But the following experiments render it probable that, if not a suboxide of platina, the powder of Liebig is either a mixture of suboxide and metal, or at least retains much oxygen in the state of adhesion, and that the absorption of hydrogen is mainly due to its conversion into water.

Five grains of the powder, prepared according to the process described by Liebig, were compressed into the end of a glass tube, and protected, by a cork removeable at pleasure, from the action of mercury, with which it rapidly amalgamates. The tube was then filled with mercury and inverted. Hydrogen in measured quantity was admitted. On withdrawing the cork and allowing contact of the gas and powder, there was a rapid absorption of the gas, with evident deposition of moisture. When the powder had ceased to act, it was found that ·49 cubic inch of hydrogen had disappeared. Supposing this diminution to be entirely due to the formation of water, five grains of the powder must have contained ·245 cubic inch of oxygen.

To the same weight of black powder ·72 cubic inch of carbonic oxide was admitted. There was a diminution to ·61, which, when washed with potassa, left ·19. Hence ·42 cubic inch of carbonic oxide had been converted into carbonic acid, for which ·21 cubic inch of oxygen are required, a number according as nearly as can be expected with that given by the former experiment †.

But if we even admit the powder of Liebig to be metallic platina in a finely divided state, this admission will not explain the combining powers of laminated or spongy platina, which induces gaseous union, but does not absorb any appreciable volume of the separate gases. The theory of Dr. Faraday, so far at least as respects the two leading principles,

* *Traité de Chimie*, tom. ii. p. 633. (6[me] edit.)

† In the few trials I have hitherto made with the powder of Liebig, its combining powers were in no degree interfered with by the presence of foreign gases. When introduced into an explosive mixture of hydrogen and oxygen, to which an equal volume of either carbonic oxide, olefiant gas, or even sulphuretted hydrogen had been added, the powder instantly glowed, and caused rapid combustion of the gaseous mixture; and when admitted into a mixture of carbonic oxide and oxygen, it occasioned instant combination with incandescence of the powder.

upon which it rests, constitutes the most satisfactory explanation hitherto proposed of this class of actions. As regards the statical relations subsisting between gases and their bounding solids, it is perfectly accordant with the analytical deductions of Laplace *; and as respects an attractive force in solids, inducing gaseous condensation on their surface, many analogous facts assembled by Mitscherlich † may be added to the numerous illustrations supplied by Dr. Faraday himself. There is, however, one element of Dr. Faraday's reasoning, the validity of which appears to me questionable. In considering the mutual relations of mixed gases, he has assented to the doctrine of Dr. Dalton in the form in which it was first proposed, viz. "that gaseous molecules are only self-repulsive, or that the particles of one gas are indifferent to those of another gas." But this doctrine, soon after its announcement in the "Manchester Memoirs," was strongly controverted; and among the objections raised against it, some were regarded by Dr. Dalton himself as sufficiently cogent to induce him, when treating the same topic in his "New System," to admit "that the phænomena of mixed gases may be accounted for without the postulatum that their particles are mutually *inelastic* ‡."

Without reiterating arguments long ago ably urged §, it may be contended, that if heat be the sole cause of repulsion, as is implied in Laplace's theory of elastic fluidity, it is impossible to admit that the atmosphere of heat surrounding the atoms of any gas A, and constituting those atoms mutually repulsive, can be indifferent to portions of the same heat associated with the atoms of another gas B. Laplace, therefore, in applying the analytical calculus to the condition of mixed gases, and of gases mixed with vapours, rejects the supposed absence of repulsion between the molecules of different gases as theoretically improbable, and as inconsistent with known phænomena ||. Finally, the admission of repulsive forces between unlike, as well as like, gaseous atoms, seems essential to the consistency of Dr. Faraday's reasoning (in section 630). For "the deficiency of elastic power" is there stated to influence union partly "by abstracting a part of that power (upon which depends their elasticity) which elsewhere in the mass of gases is opposing their

* La densité du gaz contenu dans un vase est partout la même, excepté dans les points très voisins des parois à une distance égale ou plus petite que le rayon de la sphère d'activité sensible des forces attractives et répulsives.—*Méc. Cél.*, liv. xii. § 1. tom. v. p. 93. See also p. 105.

† *Lehrbuch der Chemie*, b. i. p. 397.

‡ "New System," pp. 189 and 162. § *Ibid.* p. 150—193.

|| "Cette hypothèse est bien peu naturelle, elle est d'ailleurs contraire à plusieurs phénomènes."—*Méc. Cél.*, tom. v. p. 109 and 110. liv. xii. § 5.

combination." Unless the particles of oxygen were elastic or repulsive as respects the contiguous particles of hydrogen, elasticity could not be a force opposed to affinity, and the diminution of elasticity or repulsion by the action of the plate, could not determine the union of oxygen with hydrogen *.

Manchester, April 7, 1835.

LIX. *On the Refraction and Polarization of Heat. By* JAMES D. FORBES, *Esq., F.R.SS. L. & E., Professor of Natural Philosophy in the University of Edinburgh.*

[Continued from p. 291, and concluded.]

66. THE table generally points to a coincidence, and that as close as by the nature of the experiments we should perhaps be warranted in expecting. If there be any excess in the second column of results (which the observations with incandescent platinum might lead us to suspect), it is more than probable that it arises from some imperfection in the apparatus employed, such as the incomplete parallelism or perpendicularity of the mica plates employed to polarize, a circumstance which was not minutely attended to.

67. The result, however, is highly satisfactory, as indicating the almost exactly complementary nature of the ordinary and extraordinary pencils, as in light.

68. The somewhat complicated conditions of the variable intensities of the ordinary and extraordinary images (which it is to be recollected correspond to the Parallel and Perpendicular positions of the analysing plate) in the case of light, are easiest kept in mind by Fresnel's formulæ.

$$O^2 = F^2 \left\{ 1 - \sin^2 2\, i \sin^2 \pi \left(\frac{o - e}{\lambda} \right) \right\} \dagger$$

$$E^2 = F^2 \left\{ \sin^2 2\, i \sin^2 \pi \left(\frac{o - e}{\lambda} \right) \right\}$$

where O^2, E^2, and F^2, have the same signification as in (64), and i represents the angle between the plane of polarization and the principal plane of the crystal: $o - e$ is the difference

* In proof that the repulsion existing between unlike gaseous molecules is a force opposed to chemical union, it is worthy of remark, that of such gases as combine *spontaneously*, when simply mingled, one or both are generally found among that class which have been reduced to a liquid form, and in which the repulsive force between the constituent molecules is therefore least energetic.

† This corresponds to the formula $\frac{a^2}{2} \sin^2 2\, \Phi \left\{ 1 - \cos \frac{2\, \pi\, I}{\lambda} \right\}$ of Airy's *Tract on the Undulatory Theory*, Art. 172. Both are only restricted expressions of more general theorems.

of the retardations of the ordinary and extraordinary rays within the crystal, and λ the length of an undulation. The sum of the two is always $= F^2$.

69. Now the quantity $o - e$ may always be known by referring to the retardation, which produces the corresponding tint in Newton's rings, and which is equal to twice the distance between the plates in that experiment. For example, with the thin mica film mentioned in (56), which polarized light circularly, the tint produced (between *crossed* polarizing and analysing plates) corresponded (by Newton's table) to an interval of about five millionths of an inch between the surfaces of glass, or to a *retardation*, $(o - e)$, of ·00001 inch. The film, marked No. 2, which gave plum-red of the first order (65), gives a retardation of ·00002. The film No. 1 (65), gives ·00004 inch. From these data, then, having the value of E^2 (68), it is clear that we may calculate the value of λ, or the length of an undulation of heat*.

70. In our present case we have always made $i = 45°$; whence $E^2 = F^2 \sin^2 \pi \left(\frac{o-e}{\lambda}\right)$; and of course $O^2 = F^2 - E^2$. But in an experiment we must not use the direct indication of the multiplier, when the polarizing and analysing planes are parallel, for the total quantity or F^2; for a large proportion of the heat is not completely polarized, and in order to compare the values of E^2 and F^2, we must determine the value of each directly, that is, not only how much is depolarized, but how much is polarized by the mica plates. This I did by ascertaining alternately with the quantities of depolarization, the total intensity of the polarized part of the heat, which reached the pile. This was effected by rendering the polarizing and analysing plates parallel and perpendicular to one another; whilst the principal section of the interposed mica remained parallel to one or other, so as to exercise no depolarizing influence.

71. To illustrate this mode of investigation, I shall give as an example the very last series of experiments made on this subject, which, whilst it points out the mode of operating, will exhibit the constancy and considerable magnitude of these effects, amidst the complicated changes of condition to which the heat is subjected. The columns marked "corrected," have a small correction applied for the gradual alteration in the quantity of heat reaching the pile, which corrections are

* Of course this is only true on the supposition that rays of heat and light are equally retarded. This is not demonstrated, but it is probable that they are nearly so, since that part of the heat which accompanies the spectrum is so, and the dispersion in the case of double refraction is inconsiderable.

interpolated from the successive observations marked (1), (2), (3), &c. which are made under similar circumstances.

1835. Jan. 16.—*Source of Heat. Incandescent Platinum. Polarizing Mica Plates E and F. Film of Mica interposed, No. I.*

Position of Mica plates.	Principal Section of interposed Mica, at	Multiplier.	Total Polarization.	Depolarization.	Total Polarization corrected	Depolarization corrected	Ratio.
[E at 0°] F at 90°	45° (1)	14°·8	....	+ 2°·8			
	0	12·0	6°·0		6°·0	2°·75	100 : 46
F at 0°	0	18·0					
	45	15·3	....	— 2·7			
F at 90°	45 (2)	14·8	....	+ 2·2			
	0	12·6	4·0		4·2	2·1	100 : 50
F at 0°	0	16·6					
	45	14·2	....	— 2·4			
F at 90°	45 (3)	14·1	....	+ 2·5			
	0	11·6	4·8		4·9	2·65	100 : 54
F at 0°	0	16·4					
	45	13·4	....	— 3·0			
F at 90°	45 (4)	13·8	....	+ 2·0			
	0	11·8	4·5		4·5	2·2	100 : 49
F at 0°	0	16·3					
	45	13·8	....	— 2·5			
F at 90°	45 (5)	13·6	....	+ 2·4			
	0	11·2	4·9		5·0	2·2	100 : 44
F at 0°	0	16·1					
	45	13·8	....	— 2·3			
F at 90°	45 (6)	13·0	....	+ 2·4			
	0	10·6	5·0		5·1	2·2	100 : 43
F at 0°	0	15·6					
	45	13·5	....	— 2·1			
						Mean,	100 : 48

When the analysing plate F is said to be at 0°, it is parallel to the plate E. When the principal section of the interposed film is at 0°, it is parallel to the plane of incidence at the plate E; at 45° it is inclined 45° to that plane. The signs + and — in the column of "depolarization," indicate whether the effect of the interposed film was to increase or diminish the heat transmitted.

72. The physical meaning of the expression for the intensity of the depolarized light, $E^2 = F^2 \sin^2 \pi \left(\frac{o - e}{\lambda}\right)$ will be found to be this. When the thickness of the interposed film is such as to give a retardation of 0, λ, or any whole multiple of λ, E is equal to nothing, or no light is depolarized, and between those values the amount of E^2, or the intensity of the depolarized light, will gradually increase from the values 0,

λ, 2λ, &c. to the values $\frac{\lambda}{2}$, $\frac{3\lambda}{2}$, $\frac{5\lambda}{2}$, &c. and again diminish in the same manner to the next limit. When the retardation is $\frac{\lambda}{4}$, $\frac{3\lambda}{4}$, $\frac{5\lambda}{4}$, &c., half the light exactly is depolarized; it is then circularly polarized; in other cases, it is plane or elliptically polarized.

73. Similar effects might be expected to occur in the case of heat. But we must recollect that it is even more difficult to obtain *homogeneous heat*, than *homogeneous light*, and that we shall have portions of heat differently depolarized by the same plate, (in consequence of the different character of refrangibility, indicating a different length of undulation,) exactly as when we operate upon white light. We know that heat of various degrees of refrangibility constitutes the solar heat, and probably all other kinds. Hence, no one plate can completely depolarize all these varieties. As far as my experiments go, made similarly to that of (71), heat unaccompanied by light is generally *less* depolarized by a plate of given thickness than heat vividly luminous. In the case of contrasting heat from an Argand lamp with that from incandescent platinum, and heat quite dark, this is strikingly marked, though not so decisively in comparing the two last kinds. If the inaccuracy be not in the experiments, it may very probably arise from the want of homogeneity in the heat just alluded to. The want of any apparent depolarizing power for dark heat in the thin mica film mentioned in (56) is now easily explained. Its thickness was such as to polarize (nearly) circularly, the mean luminous rays. Its retardation, or $o - e$ was then $= \frac{\lambda}{4}$ for these rays. But we know from Melloni's experiments, that the heating rays are *less* refrangible than the luminous rays (I mean in heat from terrestrial sources, as well as that of the solar rays), and that generally in proportion to this obscurity. Therefore, on the undulatory hypothesis, their waves are longer. Hence a retardation of $\frac{\lambda}{4}$ for light, would be a retardation of less than $\frac{\lambda}{4}$, if λ be the length of a wave of heat from an Argand lamp; it would be still less for heat from incandescent platinum, and least of all for dark heat; hence, as the retardation is a smaller fraction of λ or approaches zero, the depolarization or the value of E^2 approaches zero. This perfectly coincides with the experiment of (56).

74. Without attaching much weight to the *numerical* accu-

racy of the following results, it is worth quoting them as confirming the general fact, that obscure heat has longer undulations than luminous heat. The numbers derived from plate No. 2. (see 65,) are most to be depended upon, and the agreement of the different series made with dark heat is highly satisfactory. The numbers correspond to those of the last column in the example of (71).

Mica Plate, No. 1. *Retardation for Light,* or $o - e =$ ·00004 *inch.*	Number of Comparisons.	Ratio of Total Polarization and Depolarization or $F^2 : E^2$.
Argand lamp, ...	4	100 : 80
Incandescent platinum,...	4	100 : 78
Brass about 700°,.........	4	100 : 69
Mica Plate, No. 2. *Retardation for Light,* or $o - e =$ ·00002 *inch.*		
Argand lamp, ...	3	100 : 66
Incandescent platinum,...	6	100 : 47
Brass about 700°,.........	7	100 : 52
Ditto, ...	4	100 : 51
Mercury about 500°, ...	5	100 : 52

In discussing these observations, it would be necessary to attend to the remark of (73), respecting the want of homogeneity in the heat.

75. From the last series it appears that a plate of mica which transmits by polarized light (when the polarizing plates are crossed) red of the first order, almost exactly circularly polarizes obscure heat, for it depolarizes half the heat. The characteristic property of circularly polarized light was observed, viz. that little or no difference of result was obtained whilst the mica film was interposed (its principal section being inclined 45° to the plane of polarization), whether the analysing plate was at 0° or 90°. With incandescent platinum the effect is exceedingly striking; for, if the mica film be at 0°, the polarizing effect on crossing the plates is about 40 per cent. of the whole.

76. It is almost unnecessary to add, that what we have now said, inferring the undulatory theory of light to be true, might be translated into the language of the Newtonian theory of emission.

77. In conclusion, I would recapitulate the chief results at which I have arrived*.

* These conclusions were stated nearly in their present form (excepting the 6th), to the Royal Society [of Edinburgh] at their meeting of the 5th January. The whole of the experiments detailed in this paper (excepting only the repetition of M. Melloni's experiment on the refraction of heat (16), were made between the 22nd November and the 16th January, but all the general consequences had been clearly made out before the close of 1834.

1. Heat, whether luminous or obscure, is capable of polarization by tourmaline.

2. It may be polarized by refraction.

3. It may be polarized by reflection.

4. It may be depolarized by doubly refracting crystals. Hence,

5. It is capable of double refraction, and the two rays are polarized. When suitably modified, these rays are capable of interfering like those of light.

6. The characteristic law of depolarization in the case of light holds in that of heat, viz. that the intensities in rectangular positions of the analysing plate, are complementary to one another.

7. As a necessary consequence of the above, confirmed by experiment, heat is susceptible of circular and elliptic polarization.

8. The undulations of obscure heat are probably longer than those of light. A method is pointed out for deducing their length numerically.

78. Of the evidence for these conclusions I have enabled the reader to judge, by specifying numerical results. But I must further add, that all the principal conclusions were arrived at by the indications of the galvanometer, observed by the naked eye, including the chief phænomena of depolarization. Since I thought of the method of magnifying the divisions (described in (5),) I had little else to perform than the agreeable task of verifying and defining my first conclusions.

Edinburgh, 19th January, 1835.

LX. *Proceedings of Learned Societies.*

ROYAL SOCIETY.

1835, Feb. 19.—A PAPER was read, entitled, "On the probable Position of the South Magnetic Pole." By Edward Rudge, Esq., F.R.S., &c.

The recent discovery of the site of the North Magnetic Pole, which has resulted from the experiments of Capt. James Ross, suggested to the author the inquiry whether any similar indications of an approach to the South Magnetic Pole can be gathered from any observations now on record. With this view a table is given of the observations made by Tasman in 1642 and 1643, during his voyage of discovery in the Southern Ocean, extracted from his journal; from which it appears that he on one occasion noticed the continual agitation of the horizontal needle, in south latitude 42° 25′, and longitude from Paris 160°. On the presumption that the South Magnetic Pole was at that time near this spot, and that it has since been retrograding towards the East, the author conjectures that it will now be found

in or about the 43rd parallel of south latitude; and to the south-east of the Island of Madagascar, a situation extremely convenient for ascertaining its exact position, which he considers as an object of great theoretical as well as practical importance.

The reading of a paper was then commenced, entitled, "An Experimental Inquiry into the Cause of the grave and acute Tones of the Human Voice." By John Bishop, Esq. Communicated by P. M. Roget, M.D., Sec. R.S.

February 26.—The reading of a paper, entitled, "An Experimental Inquiry into the Cause of the grave and acute Tones of the Human Voice." By John Bishop, Esq. Communicated by P. M. Roget, M.D., Secretary to the Royal Society, was resumed and concluded.

The author considers all the theories hitherto proposed respecting the functions of the organs of the human voice, as not only unsatisfactory, but as being founded on erroneous views. He shows that the modulation of the tones of the voice is not the result of variations either exclusively in the length or in the tension of the vocal chords, or in the size of the aperture of the glottis, or in the velocity or the temperature imparted to the air in its transit through these passages. He regards the organs of the voice as combining the properties of wind and of stringed musical instruments; and shows, first, that for the production of any musical tone it is necessary that the vocal chords should previously be made mutually to approximate; and, secondly, that the muscular forces acting on the arytenoid cartilages and vocal chords are adequate not only to resist the pressure of the column of air issuing from the lungs, but also to render either the whole or certain portions of the vocal chords susceptible of vibration when traversed by the current of respired air. In proportion as these parts of the vocal chords, thus rendered vibratory, increase in length, the number of their vibrations, performed in a given time, diminishes, and the tone of the sound emitted becomes, in consequence, more grave; and, conversely, the tone is more acute as the vibrating portions of the chord are shorter: these phænomena being precisely analogous to those which take place in stringed musical instruments.

The author concludes his paper with some observations on the comparative physiology of the voice; and on the extensive range and superior excellence of this faculty in man.

March 5.—A paper was read, entitled, "A new Method of discovering the Equations of Caustics." By G. H. S. Johnson, M.A., Tutor of Queen's College, Oxford. Communicated by the Rev. Baden Powell, M.A., F.R.S.

Peculiar difficulty has hitherto attended the determination of the equation of the curve formed by the perpetual intersection of rays, which, diverging from a luminous point, are reflected by a polished surface of a given curvature. Curves of this description have been denominated caustics; and the method usually employed to discover their polar equations, or the relation between the radius vector of any point of the curve and the tangent at that point, is both long and inelegant, and is considered by the author as involving considerable inaccuracy of reasoning. He proposes, therefore, to substitute a new

method of investigation, by taking the polar equation of one of the reflected rays, and differentiating this equation with respect to the arbitrary quantities solely which determine its position, and thus obtaining the polar co-ordinates of the point of intersection of two consecutive lines; and finally, by elimination, the equation of the curve in which all such points are found. He is thus led to results remarkable for their simplicity, elegance, and generality: and he gives particular applications of his method, exemplifying the facility with which it effects the solution of problems extremely difficult of management by the ordinary methods hitherto employed. His method is also applicable to the determination of the equations of the evolutes of curves, and to various other problems of a similar nature.

A paper was also read, entitled, "Discovery of the Metamorphoses in the second Type of the Cirripedes, viz. the *Lepades*, completing the Natural History of these singular Animals, and confirming their affinity with the Crustacea." By J. V. Thompson, Esq., F.L.S., Deputy Inspector General of Hospitals. Communicated by Sir James Macgrigor, Bart., M.D., F.R.S.

The discoveries made by the author of the remarkable metamorphoses which the animals composing the first family of the Cirripedes, or *Balani*, undergo in the progress of their developement, and which he has published in the third number of his Zoological Researches (p. 76), are in the present paper, which is intended as a prize Essay for one of the Royal Medals, followed up by the report of his discovery of similar changes exhibited by three species of two other genera of the second tribe of this family, namely, the *Lepades*. The larvæ of this tribe, like those of the Balani, have the external appearance of bivalve Monoculi, furnished with locomotive organs, in the form of three pairs of members, the most anterior of which are simple and the other bifid. The back of the animal is covered by an ample shield, terminating anteriorly in two extended horns, and posteriorly in a single elongated spinous process. Thus they possess considerable powers of locomotion, which, with the assistance of an organ of vision, enable them to seek their future permanent place of residence. The author is led from his researches to the conclusion that the Cirripedes do not constitute, as modern naturalists have considered them, a distinct class of animals, but that they occupy a place intermediate between the Crustacea decapoda, with which the Balani have a marked affinity, and the Crustacea entomostraca, to which the Lepades are allied; and that they have no natural affinity with the Testaceous Mollusca, as was supposed by Linnæus, and all the older systematic writers on Zoology.

March 12.—Continuation of a former paper "On the twenty-five feet Zenith Telescope, lately erected at the Royal Observatory;" by John Pond, Esq., F.R.S., Astronomer Royal.

For determining the place of any star passing the meridian near the zenith, at the Royal Observatory at Greenwich, three different methods may be employed: first, by means of the mural circles; secondly, by the zenith telescope, used alternately east and west; and lastly, by means of a small subsidiary angle, as described by the author in a former paper. The details of computations made according

to each of these three methods are contained in the present paper; from which it appears that they all give results nearly identical; and that, when the observations with the two circles are made with sufficient care, the greatest error to be apprehended does not exceed the quarter of a second.

"Remarks towards establishing a Theory of the Dispersion of Light." By the Rev. Baden Powell, M.A., F.R.S., Savilian Professor of Geometry in the University of Oxford.

In an abstract of M. Cauchy's Theory of Undulations, published in the London and Edinburgh Journal of Science*, the author of the present paper deduced a formula expressing precisely the relation between the length of a wave and the velocity of its propagation; and showed that this last quantity is, in fact, the same as the reciprocal of the refractive index. The author here examines, by means of this formula, the relation between the index of refraction and the length of the period, or wave, for each definite ray, throughout the whole series of numerical results which we at present possess; and the conclusion to which he arrives from this comparison, for all the substances examined by Frauenhofer, viz. for four kinds of flint glass, three of crown glass, water, solution of potash, and oil of turpentine, is that the refractive indices observed for each of the seven definite rays are related to the length of waves of the same rays, as nearly as possible according to the formula above deduced from Cauchy's theory. For all the media as yet accurately examined, therefore, the theory of undulations, as modified by that distinguished analyst, supplies at once both the law and the explanation of the phænomena of the dispersion of light.

March 19.—A paper was read, entitled, "Some Account of the Eruption of Vesuvius, which occurred in the month of August, 1834, extracted from the manuscript notes of the Cavaliere Monticelli, Foreign Associate of the Geological Society, and from other sources; together with a Statement of the Products of the Eruption, and of the Condition of the Volcano subsequently to it." By Charles Daubeny, F.R.S., F.G.S., and Professor of Chemistry in the University of Oxford.

It appears, from the information collected by the author, that for a considerable time previously to the late eruption of Vesuvius, stones and scoriæ had been thrown up from the crater, and had accumulated into two conical masses, the largest of which was more than two hundred feet in height. On the night of the 24th of August last, after the flow of considerable currents of lava, a violent concussion took place, followed by the disappearance of both these conical hillocks, which, in the course of a single night, were apparently swallowed up within the cavities of the mountain. Fresh currents of lava continued to flow for several days subsequently, destroying about 180 houses, spreading devastation over a large tract of country, and destroying all the fish in the neighbouring ponds and lakes. After the 29th of August, no further signs of internal commotion were manifested, with the exception of the disengagement of aqueous and aëriform vapours from the

* See our present volume, p. 16 *et seq.*

crater, a phænomenon which, in a greateror less degree, is at all times observable. The author descended twice into the interior of the crater, which then presented a comparatively level surface; its sides consisting of strata of loose volcanic sand and rapilli, coated with saline incrustations of common salt, coloured red and yellow by peroxide of iron. The vapours which issued from various parts of the surface, collected and condensed by means of an alembic introduced into the ground, were found to consist principally of steam and muriatic acid, with only a slight trace of sulphureous or sulphuric acids. From a trial with solution of barytes, the author concludes that carbonic acid was also exhaled, but neither nitrogen nor sulphuretted hydrogen appeared to form any part of the gas emitted. The steam issuing from the lava contained both free muriatic acid and also muriate of ammonia, which latter salt could not be detected in the gas from the volcano itself. The author conceives that these volatile principles are entangled in the lava, and are subsequently disengaged.

March 26.—"On the Temperature of some Fishes of the Genus Thynnus." By John Davy, M.D., F.R.S., Assistant Inspector of Army Hospitals.

The author had occasion to observe, many years ago, that the Bonito (*Thynnus pelamys*, Cuv.) had a temperature of 99° of Fahr. when the surrounding medium was 80°·5, and that it, therefore, constituted an exception to the generally received rule that fishes are universally cold-blooded*. Having found that the gills of the common Thunny of the Mediterranean (*Thynnus vulgaris*, Cuv.) were supplied with nerves of unusual magnitude, that the heart of this latter fish was very powerful, and that its muscles were of a dark red colour, he was led to conjecture that it might, like the Bonito, be also warm-blooded; and this opinion is corroborated by the testimony of several intelligent fishermen. The author endeavours to extend this analogy to other species of the same family, which, according to the reports of the fishermen of whom he made inquiries, have a high temperature, and in whose internal structure he noticed similar peculiarities as in the Thunny; namely, very large branchial nerves, furnished with ganglia of considerable size. In this respect he considers that in these fishes the branchial system of organs makes an approximation to the respiratory apparatus of the Mammalia, and that it probably contributes to the elevation of temperature, resulting from the more energetic respiration which he supposes to be exercised by these organs. He, however, thinks it not improbable that these fish may possess means of generating heat peculiar to themselves, and of which at present we have no adequate idea. He conceives that the situation of the kidneys, of which a considerable portion is even higher than the stomach, and posterior to the gills, and which are of large size, and well supplied with nerves and blood-vessels, may possibly act a part in the production of an elevated temperature; but, on the whole, he is disposed to ascribe the greatest share of this effect to the superior magnitude of the branchial nerves.

* See Mr. Brayley's paper on the Distribution of the Powers of producing Heat and Light among Animals, in our last Number, p. 245.

GEOLOGICAL SOCIETY.

Feb. 4.—A paper was read, "On certain Coal Tracts in Salop, Worcestershire and North Gloucestershire," by Roderick Impey Murchison, Esq. V.P.G.S.

Pursuing the inquiry in descending order, commenced at the last Meeting, the author calls attention to certain undescribed carboniferous districts, the outlines of which he has laid down upon the Ordnance Maps.

I. "*Shrewsbury or upper Coal-measures with freshwater Limestone.*"

The author takes this opportunity of showing, that the coal-measures near Shrewsbury, which he formerly described* as containing a subordinate band of lacustrine limestone, pass up conformably into the lower member of new red sandstone, and are thus proved to constitute the uppermost portion of the carboniferous series. He has this year discovered this freshwater limestone (with the same minute Planorbis, &c.,) in a thin zone of coal-measures extending from Tasley near Bridgnorth to Coughley near Broseley, where the strata, like those near Shrewsbury, also dip conformably beneath the lower new red sandstone. Mr. Prestwich has ascertained that some of the great beds of coal of the Broseley and Colebrookdale field are worked beneath this limestone.

II. *Western Coal-field of Salop.*

The Oswestry coal-field, lying on the western borders of Shropshire, is completely separated from that of Shrewsbury, and is the southern termination of the carboniferous zone, which extends from Flintshire by Ruabon and Chirk. It is of small extent, and little productive, containing only one bed of good coal. The millstone grit, which rises from beneath it on three sides, is remarkable for containing beds of cherty breccia, courses of sandy, encrinital limestone, and in the lower portion strata of thick-bedded, red sandstone, in parts undistinguishable from the new red sandstone. The carboniferous limestone beneath this red sandstone, is exhibited on a very large scale in the fine escarpments of Llanymynech, Porth-y-wain and Treflach. The upper part is somewhat magnesian, and contains few fossils, with thin veins of copper ore; the lower is a fine subcrystalline limestone, in which are found *Producta hemisphærica*, the large basaltiform Coral, and many other fossils characteristic of the formation. Faults are numerous, and in the principal one running from north by east to south by west, the coal is upcast 180 yards. These dislocations increase as they rise upon the hill sides, and decrease as they range towards the plains of Shropshire.

III. "*Central and Southern Coal-fields of Salop.*"

The author mentions that he has accumulated many new facts respecting the coal-fields of the Clee Hills, since his communications in 1832, the principal of which are, That at the Titterstone Clee, the new works established by Mr. Lewis, have proved the existence of productive coal seams under the Hoar Edge, on the western side of

* Geol. Proceedings, vol. i. p. 472.

the great basaltic dyke. He corrects the observation formerly made that some of the faults which affect the elevated tract of the Brown Clee Hills are the fissures of eruption of the basalt which crowns their summit. These faults, running from north to south and traversed by others trending from east to west, are all upcasts, and contain no basaltic matter, the chief eruption of which is supposed to have taken place at the north end of the Abdon Burf. Various details are given respecting this poor coal tract, which, though interesting in the theory of the formation of coal basins, cannot be included in an abstract. The mountain limestone is entirely absent, the coal resting on old red sandstone, as previously remarked by Mr. Wright of the Ordnance Survey.*

IV. *Forest of Wyre.*

In this tract are comprehended all the carboniferous strata ranging from two miles south-west of Bridgnorth to the Abberley Hills, the central and broadest portion of which is called the Forest of Wyre. The outline of this coal tract is very irregular, and the measures rest upon and are surrounded by the old red sandstone, except near Bewdley, where they are flanked by the new red sandstone, and on the sides of the Abberley Hills, south of the Hundred-house, where they have been deposited in thin patches upon transition rocks. Accounts are given of the different seams of coal and layers of ironstone which have been worked, near Deux Hill, Billingsley, Stanley, Mamble, Pensax, &c. The greater part of these works, including all the deep shafts, are abandoned, owing chiefly to the poor and pyritous quality of the coal. Sweet coal is of rare occurrence, though some thin beds occur at Lower Harcourt near Kinlet. These sulphureous coals are little used, except for drying hops and burning lime; but the sandstones, though only partially quarried, afford excellent building material. Some peculiar conglomerates, having a matrix of decomposed trap, occupy the lower beds of the series south of Bewdley. In general the strata are much disturbed, and the structure of the country is rendered obscure by protruded bosses of the underlying old red sandstone and its associated marls and cornstone. In some cases the old red sandstone (as on the Borle Brook), constitutes the sides of narrow ravines, on the flanks and in the hollows of which the coal is thrown off at high angles of inclination. At Kinlet the coal-measures are perforated by a wide and extensive mass of basalt, the structure of which has been previously described†, and in the neighbourhood of this rock they are much hitched and broken, the sandstones being in parts converted into a hard siliceous rock called White Jewstone. At Arley, on the Severn, coal-measures, surrounded by old red sandstone, extend in a peninsulated form from the left bank of the river, and are bisected by the trap dyke of Shatterford. Another large mass of trap consisting of concretionary compact felspar was last year discovered by the author at Church Hill, 5 miles south of Cleobury Mortimer, but its relations to the adjoining

* Geol. Proceedings, vol. ii. p. 7.

† Geol. Proceedings, vol. ii. p. 92.

coal-field cannot be detected. The great fault at Stanley, near Higley on the Severn, has been caused by an upcast of the old red sandstone, which there occupies both banks of the river, abruptly cutting off the coal-measures. Allusion is then made to a short notice* of this tract, in which concretionary calcareous rocks are described as being *subordinate* to these coal-measures, but Mr. Murchison shows that these rocks are nothing more than protruding masses of cornstone of the inferior old red sandstone. He further describes, in detail, a section extending from one of these masses of concretionary limestone near Kinlet to Prescot Bridge. In this section there is a full development of the superior group of the old red sandstone, which although incoherent and of a yellow colour, and therefore unlike the prevailing rocks of that formation, is seen to pass upwards into a conglomerate, and dip under the true carboniferous limestone of Orelton. It is this tract of old red sandstone which separates the stinking-coal-fields of Bewdley Forest from the productive coal-fields of the Clee Hills.

V. "*Coal-field of Newent, North Gloucestershire.*"

The carboniferous strata are here so little developed as scarcely to entitle them to the name of a coal-field, being composed of merely a few carbonaceous beds, interposed between the new and old red sandstones. In the vicinity of the town of Newent, where the formation is most expanded, four thin seams of coal were formerly worked, which were separated from each other by only a few yards of shale. In some cases the coal was extracted from beneath the new red sandstone. The extension of these carbonaceous strata is cut off in the south and south-west by the transition rocks of May Hill; while to the north they gradually taper away, and are absolutely seen to thin out between the escarpment of new red sandstone and the argillaceous marls of the old red; hence the author concludes that the Newent coal strata were originally deposited upon old red sandstone, in a similar manner to those of the Brown Clee Hills, the Forest of Wyre, &c. &c.

In concluding his reports upon these detached coal-fields, the author gives the following as the positions which he has attempted to establish:

1st, The existence of a younger zone of coal, which contains a peculiar freshwater limestone, and passes upwards into the oldest strata of the new red sandstone, (Shrewsbury coal-field.); and downwards into the inferior coal strata of Coalbrook Dale.

2ndly, That the inferior coal strata were deposited in some parts upon mountain limestone and in others upon the old red sandstone and transition rocks.

3rdly, That the Clee Hill fields exhibit only the lower system, graduating down in two situations to mountain limestone, and in others resting upon old red sandstone.

4thly, That in the Brown Clee Hills, the Forest of Wyre, and at Newent, the carbonaceous matter was originally deposited upon the old red sandstone.

* Geol. Proceedings, vol. ii. p. 20.

5thly, That in some of the poor and ill-consolidated coals, particularly in the upper zone, the traces of vegetable organization are so distinct, that even the generic and specific characters of the plants can be recognised in the coal itself.

Lastly, That wherever the mountain limestone has been interpolated between the bottom coal grits and the old red sandstone, it can invariably be traced to thin out and disappear within a very small area; and hence it is inferred, that as calcareous matter appears never to have been elaborated in these regions, except at wide intervals and in minute quantities, mighty convulsions are not necessary to account for the absence of the mountain limestone through such large carboniferous tracts.

The coal-field of Oswestry is not included in the application of these inferences; for, like the great coal basin of South Wales, it has been deposited upon a thick girdle of carboniferous limestone.

LINNÆAN SOCIETY.

March 3rd and 17th.—Read a paper by the Rev. Patrick Keith, F.L.S., on the Classification of Vegetables,—or *Taxonomy*, as the writer proposes to call it. After noticing the limited and imperfect use of artificial methods of classification, as pointed out by Linnæus himself, whose well-known maxim is "Methodus naturalis ultimus botanices finis est et erit," Mr. Keith insists on the superiority of an arrangement founded on general structure rather than number of parts; and gives his opinion that there is but one system which is natural, and that that system is Jussieu's. After enumerating some of the principal supporters of this system, he mentions our celebrated countryman Brown as at the head of those by whom it has been elucidated and perfected;—paying at the same time a deserved tribute to the merits of Mr. Don. He then proceeds to comment upon writers who in his judgement have innovated upon Jussieu's nomenclature and arrangement; and, after some observations on Professor Lindley's *Nixus Plantarum*, and the *circular* arrangements, concludes with a tabular sketch intended to adapt the system of Jussieu to the present state of botanical knowledge, without innovating upon its principles.

April 7th.—Read a communication by George Bentham, Esq., F.L.S., entitled, "On the Eriogoneæ, a tribe of the order Polygoneæ."

This group, which is exclusively American, is distinguished from the rest of the order by the presence of an involucrum, and by the entire absence of the sheathing stipules from the leaves. The *Eriogoneæ* agree with *Rheum* and *Oxyria* in having a straight embryo placed in the axis of the albumen. The group consists of three genera, namely, *Eriogonum*, distinguished by its many-flowered involucrum; *Chorizanthe*, a genus proposed by Mr. Brown, and distinguished from the former by having a single-flowered involucrum; and lastly, *Mucronea*, characterized by its bidentate involucrum, composed of two confluent bractes. Mr. Bentham describes twenty-four species of *Eriogonum*, eleven of *Chorizanthe*, mostly from Chile, and one of *Mucronea*. The great accession of new species is chiefly the result of the labours of the late Mr. Douglas in California, and of Mr. Cuming in Chile.

April 21.—Read "Observations on the Species of *Fedia*." By Joseph Woods, Esq. F.L.S.

This genus was included by Linnæus in *Valeriana*, and several of the species were combined by him under the denomination of *V. Locusta*, erroneously considering them as forming but varieties of one species. The genus is distinguished from *Valeriana* by habit, and by the structure of its fruit, which is always destitute of the feathery crown peculiar to the former. The far greater part of the species are natives of Europe, and Mr. Woods in the paper before us gives the character of twenty-one species, arranged according to the divisions proposed by De Candolle, and he has united with them the *Fedia Cornucopiæ* separated by De Candolle as a distinct genus, from its corolla being furnished with a lengthened filiform tube and an irregular limb.

The paper is illustrated by figures of the fruit of the various species.

ZOOLOGICAL SOCIETY.

[Continued from p. 230.]

October 14, 1834.—A letter was read, addressed to the Secretary by Sir Robert Ker Porter, Corr. Memb. Z.S., dated Caraccas, July 24, 1834. In reference to the *Tortoises* (*Testudo Carbonaria*, Spix,) presented to the Society by the writer in the spring of the present year (see Lond. and Edinb. Phil. Mag. vol. v. p. 233), it stated that they are regarded as a great delicacy at Caraccas, and sold as such in the market.

A letter was read, addressed to the Secretary by the Hon. Byron Cary, dated His Majesty's ship Dublin, Sept. 25, 1834, giving some particulars relative to a large specimen of the *Tortoise* from the Gallapagos Island, presented by the writer to the Society. The specimen weighs 187 lbs. and measures in length, over the curve of the dorsal shell 3 feet 8½ inches, and along the ventral shell 2 feet 3½ inches, its girth round the middle being 6 feet 3½ inches. It is consequently much smaller than several specimens of the *Indian Tortoise* from the Seychelles Islands which have at different times been exhibited in the Society's Garden; the weight and measurements of one of which are given in our report of the Society's Proceedings on the 9th of July 1833; Lond. and Edinb. Phil. Mag., vol. iii., p. 300, The lateral compression of the anterior part of the dorsal shell, and the elevation of its front margin, by which the *Gallapagos Tortoise* is distinguished from the *Indian*, are in this specimen strongly marked.

Some notes by Mr. Martin of the dissection of a specimen of the *Mangue* (*Crossarchus obscurus*, F. Cuv.) were read.

"The dissection was strongly confirmatory," Mr. Martin observed, "of the justice of the position claimed for the animal, notwithstanding its plantigrade mode of progression, between the *Ichneumons* and the *Suricates*. To the latter indeed it bears in its general external aspect and characters a marked affinity; in both we find the pupil circular, and the muzzle elongated, pointed, and moveable. Nor is there much less correspondence in their general anatomy." The details are given in the 'Proceedings' of the Society.

A collection was exhibited of skins of *Birds*, formed by B. H. Hodgson, Esq., Corr. Memb. Z.S., in Nepal, and presented by him

to the Society. These birds were brought under the notice of the Meeting by Mr. Gould, who, at the request of the Chairman, pointed out the most interesting among them, both as regarded the Society's collection, and with reference to their novelty or the peculiarities of their form. As, however, Mr. Hodgson himself purposes to describe at length the characters and habits of the several species in his proposed 'Zoology of Nepal,' Mr. Gould abstained from entering more particularly into those topics.

A paper was read "On *Clavagella*, by W. J. Broderip, Esq." It was accompanied by drawings illustrative of the new species described in it.

The author commences by a history of the genus from the time when Lamarck established it for the reception of four fossil species, two of which he had previously referred to his genus *Fistulana*. A recent species was subsequently described and figured by Mr. G. B. Sowerby, in his 'Genera of Recent and Fossil Shells,' under the name of *Clav. aperta*; and a second recent species, *Clav. Australis*, has since been described and figured by the same conchologist; M. Audouin has noticed another recent *Shell* which he refers to this genus; and some details have been published by M. Rang of an additional recent species, his *Clav. Rapa*. The collection of Mr. Cuming furnishes another recent species, the anatomy of which formed the subject of a paper read by Mr. Owen at the last Meeting of the Society; there exists yet another in that of Mr. Isaac Lyon Goldsmid; and another in those of Mr. Cuming and Mr. Miller.

A close examination of the recent species which he has observed has convinced Mr. Broderip that although one valve of the shell is always fixed or imbedded in the chamber formed in the hard surrounding substance, the tube is not necessarily continued into a complete testaceous clavate shape, and that consequently the character assigned by Lamarck to the genus requires emendation. The fixed valve is in all these species continued on to the tube. In Mr. Cuming's the perforated shelly plates are situated not far from the throat of the tube, one on either side; while in Mr. Goldsmid's the perforated plate is single, and seated at the anterior or greater end of the ovate chamber, being in the smaller individual joined laterally to the anterior ventral edge of the fixed valve, and in the larger one wholly isolated from it. In all the specimens the anterior edge of the fixed valve is surrounded by the naked wall of the chamber.

After remarking on the difficulty of clearly defining species where the roughness or smoothness of the surface of the shell and even its shape may depend upon the greater or less degree of hardness of the material of which the chamber is formed; where colour also is absent; and from specimens of which the tubes are broken; Mr. Broderip proceeds to suggest the following distinguishing characters. The first two may, he remarks, hereafter prove to be mere varieties, although he is strongly disposed to regard them as constituting distinct species:

Clavagella elongata. *Clav. camerâ elongato-ovatâ; valvâ liberâ*

elongatâ, subtrigonâ, convexâ, externè concentricè valdè rugosâ, intùs nitente; umbone acuto.

Hab. in Oceano Pacifico?

Mus. Goldsmid.

The wall of the coral chamber against which the free valve rested gives as exact an impression of the external rugosities of that valve as if the valve had been applied to a surface of wax.

Clavagella lata. *Clav. camerâ rotundato-ovatâ; valvâ liberâ latiusculâ, subtrigonâ, subconvexâ, externè concentricè rugosâ, intùs nitente; umbone subrotundato.*

Hab. in Oceano Pacifico.

Mus. Cuming.

Both valves are nacreous internally; and the muscular impressions, especially in the fixed valve, are very strong.

Clavagella Melitensis. *Clav. testâ subrotundatâ, rugosâ, intùs subnitente; tubo longitudinaliter corrugato.*

Hab. ad Melitam.

Muss. Cuming, Miller.

It is not impossible, from its locality, that this may turn out to be M. Audouin's species, if that should prove to be a true *Clavagella*. M. Sander Rang's remarks, however, go far to show that a Sicilian *Shell* referred to this genus, has been incorrectly so referred, in as much as it has no fixed valve. The one described above has the fixed valve continued on to the shelly tube as in the other recent species of the genus *Clavagella*.

Mr. Broderip conjectures that *Clavagella* may be in its very young state a free *Bivalve*, floating at large until it arrives at some vacant hole that suits it, when it attaches one valve to the wall of the hole, and proceeds to secrete the tube or siphonic sheath, to enlarge the chamber according to its necessities, and to secrete the shelly perforated plate which is to give admission to the water at the practicable part of the chamber. The excavation may probably be assisted by the secretion from the glands observed by Mr. Owen, and evidently cannot be effected in the greater end of the chamber by mere mechanical attrition; but the solvent secretion must be one of extensive powers to act on such different substances as siliceous grit, the coral of an *Astræopora*, calcareous grit, and argillo-calcareous tufa, in which respectively were found the *Clav. Australis*, *Clav. elongata*, *Clav. lata*, and *Clav. Melitensis*.

Adverting to the different depths at which these several species were found, which varied from near low-water mark to sixty-six feet, Mr. Broderip remarks, that inferences as to the state of submersion of a rock during the lifetime of the fossil species which there occur, ought consequently to be made with caution by the geologist.

In conclusion he observes, that though the genus *Clavagella* is in its recent state at present rare, it is in all probability widely diffused; and suggests to collectors a careful examination of masses of coral and submerged perforated rocks with a view to the further elucidation of the habits and structure of these and other interesting animals.

October 28.—Living specimens were exhibited of a species of *Bee* from South America, together with portions of its Comb, contained in the fissure of a log of wood. They were presented to the Society by Mr. Bigg, who stated, in a note accompanying the specimens, that they were found about three weeks since on splitting a log of peach-wood from the Brazils for the use of a dye-house, on the premises of Mr. Applegath, a calico-printer at Crayford in Kent. The wood had been previously lying in the docks, and had been perhaps eighteen months from the Brazils.

Mr. Curtis, to whom specimens were submitted for examination, states that they belong to the genus *Trigona*, Jur., and form a very pretty and apparently undescribed species.

Mr. Yarrell exhibited preparations of both sexes of *Syngnathus Acus*, Linn., and *Syngn. Typhle*, Ej., in illustration of the following extract from the manuscript notes of the late John Walcott, Esq., author of 'A Synopsis of British Birds,' 'History of Bath Fossils,' and 'Flora Britannica Indigena.' This manuscript, which is voluminous, and relates wholly to British Fishes, was written during the author's residence at Teignmouth, in the years 1784 and 1785, and has been forwarded by his son William Walcott, Esq., of Southampton, to Mr. Yarrell, for his use in a projected work on 'British Fishes.'

"*Syngnathus Acus* and *Typhle*.—The male differs from the female in the belly from the vent to the tail fin being much broader, and in having for about two thirds of its length two soft flaps, which fold together and form a false belly. They breed in the summer, the females casting their roe into the false belly of the male. This I have asserted from having examined many, and having constantly found, early in the summer, roe in those without a false belly, but never any in those with; and on opening them later in the summer there has been no roe in (what I have termed) the female, but only in the false belly of the male."

The specimens exhibited of females of *Syngn. Acus* and *Typhle* had no anal pouch, and the opened *abdomen* exposed two lobes of *ova* of large size in each. The anal pouch is peculiar to the males, and is closed by two elongated flaps. On separating these flaps and exposing the inside, the *ova*, large and yellow, were seen lining the pouch in some specimens, while in others the hemispheric depressions from which the *ova* had been but lately removed were very obvious. In each of these the opened *abdomen* exhibited true *testes*.

Mr. Walcott adds: "They begin to breed when only between 4 and 5 inches long." A specimen of *Syngn. Acus*, nearly 16 inches long, was exhibited, indicating, probably, its extreme growth. A female of the same species, only 4 inches long, was also shown, the *abdomen* of which contained two lobes of enlarged *ova*, which, to all appearance, would have been deposited in a few days.

Specimens of males and females of *Syngn. Ophidion*, Linn., were also exhibited. In this species neither male nor female possesses an anal pouch, but the *ova* are carried by the male in hemispheric depressions on the external surface of the *abdomen*; anterior to the *anus*.

All the specimens examined having these external depressions proved to be males, with the *testes* in the *abdomen* very obvious: those without external depressions proved to be all females, internally provided with two lobes of enlarged *ova*. The males of this species, when taken by Mr. Yarrell from the sea, had one *ovum* of the size and colour of a mustard-seed fixed in each cup-shaped depression, but time and the effects of a long journey had removed them. Dr. Fleming in his 'History of British Animals,' page 176, states the length of *Syngn. Ophidion* at about 5 inches: some of Mr. Yarrell's specimens measured 9 inches.

Mr. Yarrell further stated that the males of *Syngn. Acus* carry their living young in the anal pouch, even after they have been hatched there. He had been frequently told by fishermen that on opening them they had found the living young within the pouch, which they called the belly; and that if these young were shaken out into the water over the side of the boat, they did not swim away, but when the parent fish was held in the water in a favourable position, the young would again enter the pouch.

It was observed by M. Agassiz, that the fact of the males of certain species of the genus *Syngnathus* carrying the *ova* in a peculiar abdominal pouch, after their exclusion by the female, had been noticed on the Continent by Eckström, Retzius, and Marcklin; and that he had himself made the same observation.

M. Agassiz exhibited drawings of several species of *Lepisosteus*, together with some of the details of their internal organization; and, at the request of the Chairman, explained his views with regard to their systematic arrangement and structure, as well as to their relations with various genera of fossil fishes, and the coincidence of some parts of their internal anatomy with that of *Reptiles*. He described two new species observed by him in the British Museum, taking his characters principally from the form and sculpture of the scales, the presence or absence of the short rays at the base of the caudal and other fins, and the variations in the form and disposition of the teeth. In reference to their internal structure, he particularly called the attention of the Meeting to the large and regular slit by which the swimming-bladder communicates with the *pharynx*; which he regarded as bearing even a closer resemblance to the entrance of the *trachea* of the pulmoniferous *Vertebrata* in general, than the aperture by means of which the lungs communicate with the *pharynx* in the *Perennibranchiate Amphibia*. He conceived, therefore, that the anatomy of these fishes offers a conclusive argument in favour of the theory, long since proposed, that the swimming-bladder of *Fishes* is analogous to the lungs of the other *Vertebrata*. He spoke of the number of the cæcal appendages as greater in *Lepisosteus* than in any other fish which he had dissected; and referring to certain fossil bodies by which geologists have long been puzzled, and which have been regarded as fossil worms, he stated his opinion, from the close resemblance between the two, that they are in reality the cæcal appendages of the fossil fishes, in whose company they are generally found.

Mr. Gray exhibited young shells of *Argonauta Argo* and *Arg. hians*, with the view of calling the attention of the Society to a new argument in favour of the opinion that the animal (*Ocythoë*) found in the shells of this genus is parasitic. This argument is founded on the size of what Mr. Gray has termed the *nucleus* of the shell, viz. that original portion of it which covered the animal within the egg, and which is usually found to differ in surface and appearance from the remainder of the shell formed after its exclusion from the egg. In the specimens exhibited Mr. Gray described the *nucleus* as blunt, rounded, thin, slightly and irregularly concentrically wrinkled, and destitute of the radiating waves which are common to the adult shells of all the species of this genus. These waves he stated to commence immediately below the thin hemispherical tips, and he therefore entertained no doubt that those tips constituted the *nucleus* of the shell, and covered the embryo of the animal at the period of its exclusion from the egg. Judging from the size of this portion of the shell, which in one of the specimens measured nearly one third of an inch in diameter, and was consequently many times larger than the largest eggs of the *Ocythoë* found within the *Argonaut* shells, Mr. Gray inferred that it must have been produced by an animal whose eggs are of much greater magnitude. The *Ocythoë* cannot therefore, he conceived, be the constructor of the shell, and its true artificer still remains to be discovered. Mr. Gray further remarked, with reference to Poli's statement that he had observed the *rudiment* of a shell on the back of the embryo of *Ocythoë* examined by him, that he has himself uniformly found, in all the eggs of *Mollusca* which he has examined, the shell well developed, even before the development of the various organs of the embryo. With respect to the argument derived from the want of muscular attachment, he observed that the animal of *Carinaria* (to which he considered it probable that that of *Argonauta* is most nearly related), although firmly attached to the shell while living, separates from it with the greatest ease when preserved in spirits, being from its gelatinous nature very readily dissolved. These circumstances, he conceived, might fairly account for the animal of *Carinaria* having been, until very recently, unknown, and for that of *Argonauta* still remaining undiscovered.

November 11, 1834.—A specimen was exhibited of a species of *Monacanthus*, Cuv., remarkable for having on each side of the body, about midway between the pectoral and caudal fins, a bundle of long and strong spines directed backwards. The species was figured in Willughby's 'Historia Piscium,' and a description of it by Lister is contained in the Appendix to that work; but it appears not to have been noticed by subsequent observers, and to have been altogether overlooked or rejected by systematic writers. Lister's specimen of the *Fish* was preserved in the collection of William Courten, the founder of the museum which became subsequently the property of Sir Hans Sloane, and eventually formed the basis of the British Museum: that brought under the notice of the Meeting belongs to the Museum of the Army Medical Department at Chatham, and was exhibited with the permission of Sir James Macgrigor. It was ac-

companied by a description by Staff-Surgeon Burton, which was read.

MONACANTHUS HYSTRIX. *Mon. lateribus in medio 6—7-spinosis, spinis validis longioribus.*

Guaperva Hystrix, *List., in Will. Hist. Pisc., App. p.* 21. *Tab. S.* 21.

"Length 7 inches. Colour black. Skin crowded with rough grains; a smooth spot behind the gills; towards the tail assuming the character of rhomboid scales, but the granular form continued over the caudal fin. On the sides, about one third of its length from the tail, is fixed a cluster of six or seven strong free spines from $\frac{1}{4}$ to 1 inch in length, capable of erection and depression.

"Dorsal spine very strong, about $1\frac{1}{4}$ inch long, subtriangular, with serrated edges, and grained, except towards the point: when not erected it is lodged in a deep groove on the back. Extremity of the *pelvis* salient, and terminating in two sharp short spines. Second dorsal fin broad and 2 inches long; anal similar, but shorter.

"In front of the eyes a small *fossa* covered with a membrane, except in its centre, where it is perforated by a minute olfactory *foramen*.

"Teeth in the upper jaw eight, the two middle incisors placed directly in front of the second pair, in a groove of which they are lodged, so that no part of these last are visible externally, except a small process at the cutting edge; the outer teeth trigonal. The teeth of the lower jaw differ materially from the generic character, their number being only four, of which the two middle ones are by far the largest in the mouth. On this account, and also on account of the nature of its covering,—which partakes of the granular character of that of *Monacanthus* and *Aluterus*, Cuv., and of the rhomboidal scales of *Balistes*, Ej.,—this fish might be regarded as the type of a distinct subgenus among the *Balistidæ*.

"The strong dorsal spine, the spinous processes of the pelvic bones, and the cluster of lateral spines, added to the tough indurated *epidermis* of this fish, form an armour excellently adapted for its protection against its more powerful enemies.

"It is an inhabitant of the Indian Ocean, frequenting the shores and coral reefs. The present specimen was brought from the Mauritius by Dr. Hibbert, Surgeon, 99th Regiment. This species is stated to be also found abundantly on the western coast of Australia, where it is known to the settlers by the name of "leather-jacket," —a denomination which is probably applied to it in common with other species of *Balistidæ*."

Mr. Gray exhibited a drawing of this specimen, and stated his intention of publishing a figure of it in the concluding Number of the 'Illustrations of Indian Zoology,' which is about to appear.

Mr. Gray called the attention of the Meeting to two new species of *Sturgeon*; one from China, of which he exhibited a specimen, and the other from the Mississippi, of which he showed a drawing taken from a specimen in the British Museum. The former species belongs to the same section of the genus with the *Acipenser glaber* of Marsigli, characterized by its conical muzzle, and the smooth and silvery

nature of the skin between its 5 rows of plates. It was sent to England from China by Mr. John Russell Reeves, and was characterized by Mr. Gray as *Acipenser Sinensis.*

The other species was stated by Mr. Gray to belong to a new section intermediate between the true *Sturgeons* and the *Spatulariæ*, having a broad expanded muzzle, flat above, shelving on the sides, and concave, and furnished with a central ridge beneath. It was characterized as *Acipenser cataphractus*; Acipenser cataphractus, *Rapp, MSS. Hab.* in fluvio Mississippi.

The exhibition was resumed of the *Shells* collected by Mr. Cuming on the Western Coast of South America, and among the Islands of the South Pacific Ocean. Those exhibited at the Meeting were accompanied by characters by Mr. G. B. Sowerby, and comprehended the following apparently undescribed species of the genus Fissurella.

Fiss. *maxima* (in some specimens the internal margin shows a very great development of crystalline structure), *grandis* (long. 4, lat 2·6 poll.), *limbata* (a representation of the inside of this shell has been given in Mr. Sowerby's 'Genera of Recent and Fossil Shells,' under the name of *Fiss. picta,* Lam., from which it is nevertheless very distinct), *biradiata* (Frembly MSS.), *lata* (approaches, in form and colouring, very nearly to *Fiss. picta*, Lam.), *pulchra, oriens, Chilensis, obscura, virescens, nigro-punctata, macrotrema, affinis* (Gray), *microtrema* (the dorsal perforation so small, and the coloration so dark, that it is difficult at first sight to perceive it to be really a *Fissurella*), *inæqualis, Pica, Chemnitzii* (represented by Martini, I. t. xi. f. 100, whose figure is cited by Lamarck as a representation of *Fiss. Græca*), *latimarginata, trapezina, æqualis, fulvescens, nigrita, aspera, asperella, mutabilis, Panamensis, Ruppellii, Clypeus,* and *crenifera.* The characters of all these species are detailed in the 'Proceedings' of the Society.

A Letter was read, addressed by Capt. P. P. King, R.N., Corr. Memb. Z.S., to W. J. Broderip, Esq., and dated New South Wales, April 13, 1834. It gave some account of the Oceanic Birds observed during the late voyage of the writer from Europe to New South Wales, and more particularly of those of the genus *Diomedea*, Linn.

" From the meridian of the island of Tristan d'Acunha to that of the island of St. Paul's, on about the parallel of 40° of south latitude, we were daily surrounded by a multitude of oceanic birds.—Of the *Petrel* tribe the *Cape Pigeon, Procellaria Capensis,* Linn., was most abundant: but the *Proc. vittata* (vel *cœrulea*) frequently was observed; as was also a small black *Petrel* which I do not recollect to have before seen.

" Of the genus *Diomedea* the species which I regarded as the *spadicea, chlororhynchos* and *fuliginosa* of Authors, were the most remarkable. Near Tristan d'Acunha the first (*Diom. spadicea*) most abounded: between the Cape and the longitude of 30° East the second (*Diom. chlororhynchos*) became more numerous: and in the neighbourhood of St. Paul's their place was supplied by the *Diom. fuliginosa.* Where one species abounded, the others were only occa-

sionally seen; from which it may be inferred that each species breeds in distinct haunts. Occasionally two or three varieties of the *Diom. exulans*, Linn., the *large wandering Albatross*, attended the ship, but they rarely remained beyond the day. *Diom. exulans* varies very much in plumage; generally, however, the head, neck, back, and wings are more or less mottled grey, and the breast, *abdomen*, vent, and *uropygium* snowy white; the bill is horn-coloured and the feet yellow.—We saw a bird that might be referred to M. Lesson's *Diom. epomophora*, if that is really a distinct species.—Another of very large size was near us for two days, which, with the exception of the back of the wings and tips of the under side of the pen feathers and extremity of the tail being black, was of a snowy white colour."

Capt. P. P. King transmitted with his Letter characters and descriptions of three of the species of *Albatross* observed by him, including those which he regarded as the *Diomm. spadicea* and *chlororhynchos*; together with drawings of these two species. The descriptions were read, and the drawings exhibited. The former agree essentially with the descriptions from the same specimens, recently published in his 'Wanderings in New South Wales,' &c., by Mr. George Bennett, who was a fellow voyager with Capt. King. The reference of these to the species quoted is, however, provisional only, as they differ in some important particulars from the original descriptions of those species: it is therefore probable that they are rather to be viewed as indicating races hitherto unnoticed by zoologists.

Mr. George Daniell stated some facts that had fallen under his observation with reference to the habits and economy of two British species of *Bats*, the *Pipistrelle*, *Vespertilio Pipistrellus*, Geoffr., and the *Noctule*, *Vespertilio Noctula*, Schreb., dwelling more particularly on those connected with the feeding of the former, and with the period of gestation and mode of parturition of the latter.

With regard to the former species, he stated that in July 1833 he received five specimens, all of pregnant females, from Elvetham, in Hampshire. Many more were congregated together with them in the ruins of the barn in which they were taken, but all the rest escaped. They had been kept in a tin powder-canister for several days, and on being turned loose into a common packing-case, with a few strips of deal nailed over it to form a cage, they exhibited much activity; progressing rapidly along the bottom of the box, ascending by the bars to the top, and then throwing themselves off as if endeavouring to fly. They ate flies when offered to them, seizing them with the greatest eagerness, and devouring them greedily, all of them congregating together at the end of the box at which they were fed, and crawling over, snapping at, and biting each other, at the same time uttering a grating kind of squeak. Cooked meat was next presented to them, and rejected; but raw beef was eaten by them with avidity, and with an evident preference for such pieces as had been moistened with water. This answered a double purpose: the weather being warm, numbers of *blue-bottle Flies, Musca vomitoria*, Linn., were attracted by the meat; and on approaching within range of the bat's wings were struck down by their action,

the animal itself falling at the same moment with all its membranes expanded, and cowering over the prostrate fly, with its head thrust under in order to secure its prey. When the head was again drawn forth, the membranes were immediately closed, and the fly was observed to be almost invariably taken by the head. Mastication appeared to be a laboured operation, consisting of a succession of eager bites or snaps, and the sucking process (if it may be so termed) by which the insect was drawn into the mouth being much assisted by the looseness of the lips. Several minutes were employed in devouring a large fly. In the first instance the flies were eaten entire; but Mr. Daniell afterwards observed detached wings in the bottom of the box. These, however, he never saw rejected, and he is inclined to think that they are generally swallowed. A slice of beef attached to the side of the box was found not only to save trouble in feeding, but also by attracting the flies to afford good sport in observing the animals obtain their own food by this new kind of bat-fowling. Their olfactory nerves appear to be very acutely sensible. When hanging by their posterior extremities, and attached to one of the bars in front of the cage, a small piece of beef placed at a little distance from their noses would remain unnoticed; but when a fly was placed in the same situation they would instantly begin snapping after it. The beef they would eat when hungry; but they never refused a fly. In the day-time they sometimes clustered together in a corner; but towards evening they became very lively, and gave rapid utterance to their harsh, grating notes. One of them died on the fifth day after they came into Mr. Daniell's possession; two on the fourteenth: the fourth survived until the eighteenth; and the fifth until the nineteenth day. Each was found to contain a single *fœtus*.

On the 16th of May, 1834, Mr. Daniell procured from Hertfordshire five specimens of the *Vespertilio Noctula*, four females and one male. The latter was exceedingly restless and savage, biting the females, and breaking his teeth against the wires of the cage, in his attempts to escape from his place of confinement. He rejected food and died on the 18th. Up to this time the remaining four continued sulky; but towards evening they ate a few small pieces of raw beef, in preference to flies, beetles, or gentles, all of which were offered to them: only one of them, however, fed kindly. On the 20th one died, and on the 22nd two others, each of which was found to be pregnant with a single *fœtus*. The survivor was tried with a variety of food, and evincing a decided preference for the hearts, livers, &c. of fowls, was fed constantly upon them for a month. In the course of this time large flies were frequently offered to her, but they were always rejected, although one or two *May Chafers, Melolontha vulgaris*, Fab., were partially eaten. In taking the food the wings were not thrown forward as in the *Pipistrelle*; and the food was seized with an action similar to that of a dog. The water that drained from the food was lapped, but the head was not raised in drinking, as Mr. Daniell had observed it to be in the *Pipistrelle*. The animal took considerable pains in cleaning herself, using the posterior extremities as a comb, parting the hair on either side from head to tail,

and forming a straight line along the middle of the back. The membrane of the wings was cleaned by forcing the nose through the folds and thereby expanding them. Up to the 20th of June the animal fed freely, and at times voraciously, remaining during the day suspended by the posterior extremities at the top of the cage, and coming down in the evening to its food: the quantity eaten sometimes exceeded half an ounce, although the weight of the animal itself was no more than ten drachms. On the 23rd, Mr. Daniell, observing her to be very restless, was induced to watch her proceedings. The uneasiness was continued for upwards of an hour, the animal remaining during all this time in her usual attitude suspended by the posterior extremities. On a sudden she reversed her position, and attached herself by her anterior limbs to a cross wire of the cage, stretching her hind legs to their utmost extent, curving the tail upwards, and expanding the membrane interposed between it and the posterior extremities, so as to form a perfect nest-like cavity for the reception of the young. In a few moments the snout of the young one made its appearance, and in about five minutes the whole of its head was protruded. The female then struggled considerably until the extremities of the *radii* had passed, after which the young one by means of a lateral motion of its fore limbs relieved itself. It was born on its back, perfectly destitute of hair, and blind; and was attached by an umbilical cord of about two inches in length. The female then licked it clean, turning it over in its nest, and afterwards resuming her usual position, and placing the young in the membrane of her wing, proceeded to gnaw off the umbilical cord and eat the *placenta*. She next cleaned herself, and wrapped up the young so closely as to prevent any observation of the process of suckling. The time occupied in the birth was 17 minutes. At the time of its birth the young was larger than a new-born mouse, and its hind legs and claws were remarkably strong and serviceable, enabling it not only to cling to its dam, but also to the deal sides of the cage. On the 24th the animal took her food in the morning, and appeared very careful of her young, shifting it occasionally from side to side to suckle it, and folding it in the membranes of the tail and wings. On these occasions her usual position was reversed. In the evening she was found dead; but the young was still alive, and attached to the nipple, from which it was with some difficulty removed. It took milk from a sponge, was kept carefully wrapped up in flannel, and survived eight days, at the end of which period its eyes were not opened, and it had acquired very little hair. From these observations it is evident that the period of gestation in the *Noctule* exceeds thirty-eight days.

Mr. Daniell also exhibited skeletons of the male and female of the *Pipistrelle* and *Noctule Bats*, forming part of his own collection, for the purpose of pointing out a peculiarity in the female, connected, as he conceives, with the mode of parturition just described. This peculiarity consists of a prolongation of the *os calcis* along the margin of the membrane extended between the hinder extremities and the tail, of much greater length and strength in the female than in

the male. By means of this process Mr. Daniell believes the female to be capable of giving greater tension to the pouch formed of that membrane for the reception of the young in the act of parturition.

November 25.—A Letter was read, addressed to the Secretary by Keith E. Abbott, Esq., and dated Trebizond, June 20, 1834. It referred to a collection of skins of *Birds* made by the writer in his immediate neighbourhood, and presented by him to the Society. The number of species contained in the collection is twenty, one only of which was comprised among those previously transmitted by Mr. Keith Abbott, and exhibited to the Society at its Meeting on June 24, 1834. Mr. Abbott states that he proposes to continue the collection of such zoological subjects as he can procure in the neighbourhood of Trebizond, for the purpose of transmitting them to the Society.

The *Bird-skins* presented by Mr. Keith Abbott were exhibited, and Mr. Gould, at the request of the Chairman, brought them severally under the notice of the Meeting, observing on each of them as regarded its geographical distribution. The exhibition was regarded as a continuation of that which took place on June 24, (Lond. and Edinb. Phil. Mag., vol. v. p. 314.) and comprised the following species not then enumerated, making in the whole fifty-three species observed in the vicinity of Trebizond.

Falco Tinnunculus, Linn., *Otus vulgaris*, Cuv., *Sylvia Rubecula*, Linn., *Emberiza Cia*, Linn., *Alauda arvensis*, Linn., *Corvus Monedula*, Linn., *Picus medius*, Linn., *Ardea Garzetta*, Linn., *Scolopax major*, Linn., *Tringa variabilis*, *Charadrius Pluvialis*, Linn., *Charadrius Himantopus*, Linn., *Anas Querquedula*, Linn., *Anas Fuligula*, Linn., *Clangula vulgaris*, Flem., *Mergus Albellus*, Linn., *Podiceps cristatus*. Particulars of the geographical distribution of all these species, as given by Mr. Gould, will be found in the 'Proceedings.'

Mr. Gray exhibited a specimen of a *Reptile* from New South Wales, which he regarded as constituting the type of a new genus nearly related to *Bipes*, Latr. He characterized it under the name of

LIALIS.

Caput elongatum, fronte plano, squamis parvis subimbricatis vestitum: *irides* lineares, verticales: *aures* oblongæ, conspicuæ.

Corpus subcylindricum, attenuatum: squamis dorsalibus ovatis, convexis, lævibus; ventralium seriebus duabus intermediis majoribus.

Pedes duo, postici, obsoleti, acuti, ad basin 2—3-squamati.

Anus subposticus: *squamæ præanales* parvæ; *pori subanales* utrinque quatuor per paria dispositi.

This genus is very nearly allied to *Pygopus*, Merr., but may be readily distinguished from it by the characters above given. In *Pygopus* the head is short, more rounded in front, and covered with regular shields: the pupil is subcircular: the feet are broad, ovate, blunt, and covered with three rows of scales: the vent has five large oblong scales in front of it: and the subanal pores form a continuous series.

LIALIS BURTONIS. *Li. suprà pallidè cinerascenti-brunnea, nigro minutissimè punctata; subtùs pallidè cacaotico-brunnea; strigâ*

albâ utrinque a labio superiore supra oculos per nucham, alteráque latiore a labio superiore per latera ad caudæ apicem ductis. Junior. *Strigis colli lateralibus obsoletis.*

Obs. Epidermide remotâ subalbida est strigis lactescentibus.

Hab. in "Novâ Cambriâ Australi." Dr. Mair.—Muss. Chatham et Brit.

Mr. Gray also exhibited a specimen of the *New Holland Ibis* of Dr. Latham, for the purpose of directing the attention of the Meeting to the spatulate form of the feathers of its neck; a form of feather which he believes not to have been previously recorded as occurring in any *Grallatorial Bird.* In this instance they are elongated, lanceolate, and bear some resemblance to straws. The specimen was obtained from the neighbourhood of Macquarrie River.

Mr. Gray subsequently exhibited adult specimens of the *Geoemyda spinosa* and *Emys platynota,* two species of *fresh-water Tortoise* recently described by him from young individuals at the Meetings of the Society on June 24 and August 26 (present vol. p. 152). He pointed out in detail the peculiarities of the adult animals and shells, which he is about to describe in his 'Synopsis of Indian Animals'; and demonstrated on the specimen of the former the existence of those characters on which he had founded the genus *Geoemyda,* and which he had previously had occasion to observe in *Ge. Spengleri* alone, —his knowledge of the animal of *Ge. spinosa* having at the time of his proposing the genus been limited to the figure published by Mr. Bell.

In the adult individual exhibited the *sternum* was concave; and Mr. Gray, in calling particular attention to this point, took occasion to remark on it as evidencing, in an additional character to those already adverted to by him, the affinity of *Geoemyda* to the *Land Tortoises,* that genus and the genus *Cistuda,* Say, being the only genera among the *Emydidæ* that possess the concavity of *sternum* which is common to most of the species of *Testudinidæ.*

A Paper was read "On *Nycteribia,* a genus of wingless *Insects,* by J. O. Westwood, Esq., F.L.S., &c."

The author commences by remarking on the existence of certain groups of animals, generally limited in extent, which exhibit in their organization, with reference to the groups to which they naturally belong, such anomalies as have constantly proved a source of perplexity to the systematists who have endeavoured to assign to them their real place in the system of nature. In many instances the anomaly involves the transition from the structure of one group to that of the adjoining ones; such instances constituting the osculant groups of Mr. W. S. MacLeay in his 'Horæ Entomologicæ'. Of these osculant groups some exist between the great divisions of the animal kingdom; others among the classes of which each of these great divisions is composed; others again between the orders, the families, and the minor subdivisions. The genus *Nycteribia* is thus osculant not between the families or even the orders of a class, but between two of the classes themselves of the *Annulose* Sub-kingdom —the *Arachnida* and the *Haustellata.* It is remarkable, moreover, for

being exclusively confined to a parasitic existence on that equally anomalous group, the *Chiroptera* among the *Mammalia*.

Notwithstanding the comparatively unattractive appearance of the insects of this genus, the singular peculiarities of their structure have drawn upon them the attention of Latreille, Hermann, Dr. Leach, M. Léon Dufour, and Mr. Curtis, who have severally contributed much to the general stock of information respecting them. But the minuteness of the objects themselves, their unfitness for accurate examination when dried and shrivelled as specimens usually are in cabinets, their comparative rarity, and other causes, have rendered the descriptions of those distinguished entomologists in some instances unsatisfactory; and it is with the view of fully elucidating the organization of the genus and of adding to its history such facts as he has been enabled to ascertain, that Mr. Westwood offers to the Society his account of *Nycteribia*, to which he adds a Synopsis of the whole of the species that have hitherto been observed, including the characters of several not hitherto described. He enumerates the sources from whence his materials have been derived; and then proceeds to describe in great detail the structure of a new species brought from Dukhun by Col. Sykes,—a species peculiarly adapted for the purpose, both on account of its comparatively large size, 2½ lines in length, and of the fitness of the individuals for minute examination owing to their having been preserved in spirit. Of this species he has examined three individuals, all of which are females in different stages of gestation. From the *abdomen* of the one which was most advanced Mr. Westwood extracted without difficulty a hard organized white mass, nearly as large as the *abdomen* itself, of an oval form, with traces of five articulations on the sides of the body, and having at its broader end three small circular spots placed in a triangle, with two smaller ones seated at a greater distance from them. That this was the young of the *Nycteribia* in its *pupa* state cannot, he conceives, be doubted: and it may consequently be regarded as proved that these insects are pupiparous, as has indeed been conjectured from their evident connexion with the *Hippoboscidæ*.

The whole of the external organization of Col. Sykes's *Nycteribia* is described by Mr. Westwood in the greatest detail, and with continual references to those portions of the descriptions published by his predecessors, which are either vague, or incorrect, or in which they are contradictory to each other. The principal points which he has endeavoured to elucidate, in addition to the transformations which these insects undergo, are the distinction of the sexes, and consequently the sexual characters and the different organization of the *abdomen* in the sexes; the structure of the mouth, *antennæ*, and eyes; the separation of the *metasternum* and the *abdomen*; the situation and construction of the spiracles; and the nature of the serrated organs between the base of the anterior and intermediate legs. The sexual distinctions appear especially to have been misunderstood, and the author takes great pains to explain them in each of the species respectively which he has been enabled satisfactorily to examine.

Mr. Westwood concludes his Paper by a Synopsis of the Species

of the genus *Nycteribia*, comprising the following, the characters of which are given in the 'Proceedings':

Nyct. Sykesii. Long. corp. lin. 2½. Species maxima.

Nyct. Hopei. Long. corp. lin. 2.—Præcedenti valdè affinis, at minor. An illius mas?

Nyct. dubia. Nyct. Blainvillii, *Latr.*

Nyct. Blainvillii, Leach.

Nyct. Roylii.

Nyct. Dufourii. Nyct. Vespertilionis, *Dufour.*

Nyct. pedicularia, Latr.

Nyct. vexata. Nyct. Vespertilionis, Herm. *Hab.* in *Vespertilione murino* Europæ. The insect described by Hermann under the name of *Nyct. Vespertilionis* may be considered, without hesitation, as specifically distinct from our two British species, as well as from *Nyct. Dufourii,* in the structure of the male. It may possibly, however, be identical with *Nyct. pedicularia.*

Nyct. Jenynsii.

Nyct. Latreillii, Leach. *Hab.* in *Vespertilione murino* Angliæ.

Nyct. biarticulata. Phthiridium biarticulatum, *Herm.* Phthiridium Hermanni, *Leach.* Celeripes Vespertilionis, *Mont. in Linn. Trans., vol.* ix. *p.* 166. Nycteribia Vespertilionis, *Mont. in Linn. Trans., vol.* ix. *t.* 3. *f.* 5 ♀. *Hab.* in *Rhinolopho Ferro-equino* Angliæ, Germaniæ, Italiæ.—In Muss. Brit. et Dom. Stephens.—Obs. Species distinctissima, sectionem peculiarem in genere constituens.

Hermann's trivial name for this species has been restored, as well in justice to that author as with the view of obviating the confusion which has arisen from his chief description having been derived from a different species.

Mr. Westwood's Memoir was illustrated by numerous magnified figures of the different species and of the details of their external structure.*

FRIDAY-EVENING PROCEEDINGS AT THE ROYAL INSTITUTION OF GREAT BRITAIN.

January 23.—Mr. Faraday on Melloni's recent discoveries in the science of radiant heat.

January 30.—Dr. Ritchie: a comparative view of the Newtonian and undulatory theories of light.

February 6.—Mr. Faraday on the induction of electric currents.

February 13.—Mr. Landseer on a sculptured historical monument lately brought from Phœnicia.

February 20.—Dr. Grant on the development of the respiratory system in the animal kingdom.

February 27.—Mr. Brande on the manufacture of floor-cloth.

March 6.—Mr. Hosking on the construction and effect of the Plymouth Breakwater.

March 13.—Mr. Davidson on the ancient and modern state of Jerusalem.

* Mr. Westwood's Memoir has since appeared in the Transactions of the Zoological Society.

March 20.—Mr. Atherston on the Essential of poetry.

March 27.—Mr. Faraday on the manufacture of pens from quills and steel.

April 3.—Dr. Ritchie : a comparative view of the theories of electricity.

April 10.—Dr. Lardner on Halley's comet.

CAMBRIDGE PHILOSOPHICAL SOCIETY, LENT TERM, 1835.

A meeting of the Philosophical Society of Cambridge was held on Monday evening, March 2, Professor Airy, Vice-President, in the Chair. Various presents of books and other objects were laid before the Society. A Memoir, by the Rev. R. Murphy, of Caius College, was read, containing the conclusion of his Researches on the Inverse Calculus of Definite Integrals ; also a Memoir by R. Stevenson, Esq., of Trinity College, on the solution of some problems connected with the theory of straight lines and planes, by a new and symmetrical method of coordination. A communication was likewise made by W. Hopkins, Esq., on Physical Geology, in which he showed, on mechanical principles, that forces of elevation, acting on extended masses of nearly horizontal strata, would necessarily produce a double system of fissures, one in the direction of the beds, the other at right angles to that direction. In a discussion which took place afterwards, Prof. Sedgwick pointed out several districts which illustrated the truth of Mr. Hopkins's theory, viz. Flintshire, Derbyshire, the mining districts of Cumberland, &c.

March 16.—The Rev. Prof. Clark, V.P. in the Chair. A paper was read by Mr. W. W. Fisher, of Downing College, (illustrated by coloured drawings,) on the nature, structure, and changes of Tubercles. The conclusion at which the author arrived was, that tubercles are organized or organizable products, that they consist, in general, in an alteration of the structure of the organ in which they occur ; and that the changes which they undergo are essentially due to inherent vital action, the process of softening being frequently marked by the development of a new order of vessels in the diseased structure.

Afterwards Mr. Willis gave an account of his views respecting the progress of Gothic architecture, especially with reference to the formation of tracery. He noticed that Romanesque architecture differed from classical in the employment of compound arches, (instead of architraves,) several arches being placed under each other so as to form successive orders of openings. As a next step, the sides of these arches are decorated with shafts; but these are different in the North and South of Europe. In the former (as in Norman architecture) the shafts replace the edges of the openings, and are called *edge shafts* ; in Italian Romanesque the shafts are placed in the square recesses of the sides of the openings, and are *nook shafts*. When the successive orders of openings become of different forms, (as two arches under one, or trefoils under simple arches,) there is an approximation to tracery; and when the mouldings which bound the openings form bars, we have actual tracery. Hence the mullions and bars have mouldings which follow a series of subordination corresponding to the orders of open-

ings, and this subordination is clearly exhibited to the very latest period of good Gothic architecture.

March 30.—The President (the President of Queen's) in the Chair. A paper by Augustus de Morgan, Esq. of Trinity College, was read, containing remarks on the memoir of M. Abel relative to the algebraical expression of the roots of equations which are connected by the law of periodic functions.—Afterwards Mr. Whewell exhibited and explained a new Anemometer, the object of which is to measure the whole amount of the wind which blows in each direction in a given time; and thus to make measures of the wind in different times and places comparable with each other. He pointed out also how such measures might be employed so as to compose a type of the annual course of the winds at each place, and thus to solve several important problems in meteorology.

LXI. *Intelligence and Miscellaneous Articles.*

INQUIRY RESPECTING THE EXISTENCE OF PROVINCIAL LITERARY AND SCIENTIFIC INSTITUTIONS.

To the Editors of the Philosophical Magazine and Journal of Science.

Gentlemen,

I FEEL confident that the cause of Science might be promoted if those who are interested in the various departments of Geology, Natural History, &c , were acquainted with the different local Societies in the different counties of England. Should this, therefore, meet the eye of any of the secretaries or others superintending establishments of this description, they would perhaps have the goodness to send to you, free of postage or other expense, a brief outline of the objects pursued, notices of their museums, or any other details they may think requisite, with an address by which a correspondence could be carried on, on points equally interesting, and in many cases, I should anticipate, equally beneficial to all parties.

Twenty-five counties in England have Literary or Scientific Societies, and in some of them are several of a highly respectable character; but with regard to the following counties I am in ignorance:

Bedfordshire, Berkshire, Buckinghamshire, Cumberland *, Herefordshire, Hertfordshire, Huntingdonshire, Leicestershire, Lincolnshire, Monmouthshire, Northamptonshire, Rutland, and Shropshire.

A Friend to the Diffusion of Knowledge by Mutual Communication.

ON THE QUANTITY OF SOLID MATTER SUSPENDED IN THE WATER OF THE RHINE. BY LEONARD HORNER, ESQ., F.R.S.

Mr. Horner's "experiments show, that the quantity of solid matter suspended in water, which, in the mass, has a turbid appearance, may be very trifling. But the extent of waste of the land, and of the solid

* We believe that there is a Literary and Philosophical Institution at Carlisle.—Edit.

materials carried to the sea, which even such minute quantities indicate, is far greater than we might be led to imagine possible from such fractions. It is only when we take into account the great volume of water constantly rolling along, and the prodigious multiplying power of *time*, that we are able to discover the magnitude of the operations of this silent but unceasing agency. In the absence of more accurate data for my calculations, for the sake of showing how large an extent of waste is indicated by water holding no more solid matter in suspension than is sufficient to disturb its transparency, I shall assume that the Rhine at Bonn has a mean annual breadth of 1200 feet, a mean depth throughout the year of 15 feet, and that the mean velocity of all parts of the stream is two miles and a half per hour. These assumptions are probably not far distant from the truth. I shall take the average amount of solid matter in suspension to be 28 grains in every cubic foot of the water.

"If we suppose a mass of water of a foot in thickness, 15 feet in depth, and 1200 feet in length, we shall have a column across the river containing 18,000 cubic feet; and 18,000 × 28 give 504,000 grains of solid matter in that column.

"A cubic foot of distilled water weighs 437,500 grains, and if we take the solid matter as having a specific gravity of 2·50, a cubic foot of it would weigh 1,093,750 grains.

"If the river run with a mean velocity of two miles and a half in the hour, 13,200 such columns would pass a line stretched across the river every hour, and 316,800 such columns every twenty-four hours;

(1760 yards in a mile = 5280 feet, $\times 2\frac{1}{2} = 13,200$
and $13,200 \times 24 = 316,800$.)

"If 316,800 columns be multiplied by 504,000 grains, and the product 159,667,200,000, be divided by 1,093,750, (the number of grains in a cubic foot of the solid matter,) we have 145,980 cubic feet of stone carried down by the Rhine past the imaginary line every twenty-four hours,—a mass greater in bulk than a solid tower of masonry sixty feet square, and forty feet in height. If we multiply 145,980 by 365, we have 1,973,433 cubic *yards* carried down in the year; and if this process has been going on at the same rate for the last two thousand years,—and there is no evidence that the river has undergone any material change during that period,—then the Rhine must in that time have carried down materials sufficient to form a stratum of stone of a yard thick, extending over an area more than thirty-six miles square. How much further back we may legitimately carry our calculations, I leave it to those to fix, who consider that there are any data to enable us even to guess at what epoch the Rhine was different from what it now is, either in respect of the volume or the velocity of the stream, in that part of its course at least to which the present paper refers."—*Jameson's Edinburgh Philosophical Journal, No.* 35.*

* In Lond. and Edinb. Phil. Mag. vol. v. p. 211, was given an abstract of Mr. Horner's paper, as read before the Geological Society, in which is described the manner of performing the experiments, the results of which are stated above.

FALL OF A METEORITE IN INDIA, ON THE 8TH OF JUNE 1834.

We extract the following from the Proceedings of the Asiatic Society of Bengal, as given in the Journal of that Society, No. 32, for August 1834:—

"Read the following extracts of a letter from the Reverend R. Everest regarding the fall of an aërolite at Hissar.

"'Having seen in the possession of Mrs. Metcalfe of Delhi a fragment of meteoric stone, which she informed me had lately fallen near Hissar, I wrote to Capt. Parsons, Supt. H. C. Stud there, for particulars, and have now the pleasure of sending his answer to you. The fragment I have seen bears the usual external characters of meteoric stone, has the same specific gravity, viz. 3·6, and affects the magnet. There can therefore be no doubt of the fact. ROB. EVEREST.

Extract of a letter from Captain Parsons, dated Hissar, 2nd Aug. 1834.

"'I hasten to give you all the information I possess relative to the meteoric stone. It fell on the 8th of June (as far as I could ascertain), at Charwallas, a village 23 coss west of this; about 8 o'clock in the morning the sky was cloudy and the weather gusty, or approaching to a north-wester, but no rain; very loud thunder, similar to constant discharges of *heavy* artillery, was heard for about half an hour before it fell, and in the direction *with* the wind to a great distance; when the stone fell it was accompanied by a trembling noise similar to a running fire of guns. It fell in the jungle close to a palee (or herdsman), who was out with his cattle. The original weight of the stone was 12 seers; but before my man reached the place, it had been broken and pieces taken away to Bikaneer, Puttialah, &c. The piece I have is upwards of 4 seers, and if you would like to send it to Calcutta, you are most welcome to it, and I will send it to you, should you wish for it.'"

QUERIES ON SOME POINTS CONNECTED WITH THE UNDULATORY THEORY. BY A CORRESPONDENT.

To the Editors of the Philosophical Magazine and Journal of Science.

GENTLEMEN,

As every fact connected with the theory of light has at the present day assumed an unusual degree of interest from the controversy so much agitated between the corpuscular and undulatory theories, I shall be excused, I trust, in offering, through the medium of your Journal, a query as to one fact apparently having a close bearing upon the question at issue.

The fact I allude to is mentioned by Mr. Potter in a paper in this Journal, Third Series, vol. ii. p. 279, viz. that when a right-angled prism has its hypotenusal side pressed against a lens, the central black spot of Newton's rings remains visible even in the middle of the total reflection: hence Mr. Potter infers that the rings cannot be formed by interference; because, I presume, he supposes no light can be transmitted through the base of the prism at that part where total reflection takes place.

Now the query I wish to propose, which, perhaps, some of your optical readers will answer, is this: Is not this supposition un-

founded? and does not a considerable portion of light actually pass through the base of the prism and emerge at its under side, even in the space where the light is *totally* reflected, as it is usually termed? May not this be owing simply to the scattering of the rays at the surface of the glass, which even the most perfect polish cannot wholly prevent?

Whilst upon this subject I may be allowed to add, Has any philosopher examined the case of interference mentioned by Mr. Potter in the Reports of the British Association for 1833, p. 378, which is brought forward by that gentleman as at variance with the results of the undulatory theory? I must confess, as far as I understand that theory, I do not perceive how the inference is deduced from it: perhaps some of your scientific readers will throw some light on this point.

As it seems that the theory of dispersion is, at least, in a fair way to be settled by the researches of M. Cauchy (as appears from Professor Powell's valuable analysis which is in progress of publication in your Journal *), it would appear that the points I have alluded to, adding, perhaps, the question agitated by Mr. Potter as to the central stripe of the interference-bands, are the only remaining points which the undulationists have to make good. I trust, therefore, that my remarks may be the occasion of calling forth such elucidation; and remain,

Gentlemen, yours, &c. X.

DETECTION OF MINUTE PORTIONS OF SULPHUR.

M. Boutigny states that very minute portions of sulphur may be detected by mixing the substance suspected to contain it with a small portion of nitre, and projecting the mixture into a red-hot porcelain capsule. The saline matter is to be washed out with distilled water, saturated with muriatic acid, and treated with muriate of barytes; the precipitate formed, if it be sulphate of barytes, is to be mixed with a little soda and heated upon charcoal; the residue is to be placed upon a strip of silver and moistened; sulphuretted hydrogen will escape in sufficient quantity to be perceptible by the smell, and to form a black spot of sulphuret on the silver.—*Journal de Chimie Medicale*, Jan. 1835.

CONVERSION OF SUGAR INTO FORMIC ACID AND ULMIN.

M. Malagutti heated a mixture of 100 parts of sugar, 300 of water, and some grammes of nitric acid; after some hours boiling a brownish deposit was formed: after continuing the ebullition for some days the saccharine matter disappeared, and formic acid was produced; the deposit on examination appeared to be ulmin.—*Ibid.* p. 49.

SCIENTIFIC BOOKS.

Transactions of the Zoological Society, Part III. vol. i.

A Guide to Geology. (Second Edition.) By Professor Phillips.

The Earth; its Physical Condition and most remarkable Phænomena. By W. Mullinger Higgins, Fellow of the Geological Society, and Lecturer on Natural Philosophy, Guy's Hospital.

* Concluded in our last Number.—Edit.

Meteorological Observations made by Mr. THOMPSON at the Garden of the Horticultural Society at Chiswick, near London, and by Mr. VEALL, at Boston.

Days of Month. 1835.	Barometer.			Thermometer.			Wind.		Rain.	
	London.		Boston.	London.		Bost.	Lond.	Bost.	Lond.	Bost.
	Max.	Min.	8½ A.M.	Max.	Min.	8½ A.M.				
March 1	29·976	29·312	29·0	39	29	36	SW.	E.	0·15	0·11
2	30·178	29·948	29·73	48	39	33	SW.	calm	...	...
3	29·990	29·723	29·15	46	34	42	W.	W.	...	·14
4	29·882	29·718	29·39	49	34	41	W.	calm	...	·02
5	30·054	29·696	29·53	52	40	38·5	W.	NW.	·08	·05
6	29·624	29·408	28·84	50	38	43	W.	W.	·17	·29
☽ 7	29·364	28·851	28·56	46	34	44	SW.	W.	·09	·34
8	29·876	29·601	29·35	48	36	37	W.	NW.	...	·23
9	29·321	29·003	28·86	51	32	43	SE.	calm	·18	·02
10	29·726	29·473	28·93	51	38	37	W.	NW.	·05	·23
11	29·841	29·571	29·03	53	37	49	SW.	NW.	·16	·07
12	29·946	29·741	29·37	54	31	43·5	SW.	calm	·22	·04
13	30·229	30·156	29·69	56	32	40	SW.	calm	·18	·45
○ 14	30·101	30·016	29·44	60	43	45	SW.	calm	·32	·18
15	30·124	29·861	29·37	51	36	44	N.	calm	·06	·10
16	30·106	30·075	29·55	52	40	45	NW.	NW.	...	·02
17	29·950	29·790	29·47	50	39	45	W.	calm	·21	...
18	30·177	29·942	29·50	51	29	43·5	NE.	calm	...	·22
19	30·340	30·289	29·84	53	28	40	NW.	calm	...	...
20	30·366	30·327	29·80	54	44	47	SW.	calm	...	...
☾ 21	30·275	30·250	29·71	53	43	50	SW.	calm	·08	·10
22	30·325	30·292	29·78	48	35	46	NE.	N.	...	·07
23	30·305	30·269	29·88	50	38	43·5	NE.	calm	·01	...
24	30·484	30·347	29·93	48	32	44	NE.	E.	...	...
25	30·606	30·575	30·16	50	26	39	NE.	calm	...	...
26	30·516	30·373	29·98	54	28	41	W.	calm	...	...
27	30·371	30·316	29·89	52	37	44	NE.	calm	...	...
28	30·256	30·161	29·80	47	33	44	NE.	calm	...	...
● 29	30·172	30·056	29·74	47	25	43	E.	calm	...	...
30	29·914	29·828	29·48	56	28	41·5	S.	calm	...	...
31	29·832	29·820	29·35	63	47	47	SW.	calm	·01	...
	30·606	28·851	29·48	63	25	42·5			1·97	2·68

Remarks.

London.—March 1. Sleet: rain. 2. Frosty and foggy. 3. Clear and windy. 4. Bleak and cold. 5. Fine, but cold. 6. Boisterous. 7. Fine: showery: barometer very low: stormy at night. 8. Fine. 9. Heavy rain: fine. 10. Very clear: fine. 11, 12. Stormy and wet. 13. Very fine. 14, 15. Rain. 16. Fine. 17. Fine: rain at night. 18. Fine. 19, 20. Hazy: fine. 21. Slight haze: rain. 22. Cloudy: fine. 23. Cold haze. 24. Cloudy and cold. 25. Clear and cold. 26. Frosty and foggy: fine. 27. Overcast. 28. Bleak and cold. 29. Dry haze: clear and frosty at night. 30. Frosty: fine. 31. Frosty and foggy: slight rain.

Boston. — March 1. Rain. 2. Cloudy. 3. Stormy: rain early A.M.: rain P.M. 4. Fine: stormy with rain P.M. 5. Fine. 6. Fine: stormy all day: rain and lightning early A.M. 7. Fine: rain A.M. and P.M.: stormy night. 8. Stormy. 9. Fine: rain early A.M. 10. Stormy: snow and rain early A.M. 11. Stormy: rain A.M. 12. Cloudy: rain A.M. and P.M. 13. Fine. 14, 15. Rain. 16. Fine. 17. Cloudy: rain P.M. 18. Cloudy. 19, 20. Fine. 21. Rain 22, 23. Cloudy. 24—26. Fine. 27—30. Cloudy. 31. Fine.

THE

LONDON AND EDINBURGH

PHILOSOPHICAL MAGAZINE

AND

JOURNAL OF SCIENCE.

[THIRD SERIES.]

JUNE 1835.

LXII. *On the Historical Evidence of the Advance of the Land upon the Sea at the Head of the Persian Gulf; with some brief Remarks on the* Gopher-wood *of Scripture: in Reply to* Mr. Carter. *By* Charles T. Beke, *Esq., F.S.A.*

To the Editors of the Philosophical Magazine and Journal.

Gentlemen,

I REGRET that from various causes I should have been prevented from sooner replying to Mr. Carter's paper contained in the number of your Magazine for October last*.

In consequence of the time which has elapsed since that paper was written, I think it right thus briefly to refer to the original subject of discussion between us. In the number of your Magazine for August 1833†, I suggested that the word גֹּפֶר (*gópher*) was probably identical with כֹּפֶר (*kópher*); and as the meaning of the latter word is "pitch," I inferred that the עֲצֵי־גֹפֶר (*hatzé gópher*) of Gen. vi. 14.,—in the translations called *Gopher-wood*, but literally *trees of gopher*,—were "pitch-trees." Mr. Carter, in your Magazine for March 1834‡, admits it to be "highly probable" that *gopher* is, as I suggest, identical with *kopher*; but he thinks it very questionable that *kopher* means "pitch," and he consequently denies my conclusion that the *hatzé-gópher* were *pitch-trees.*

* Vol. v. p. 244. † Vol. iii. p. 103. ‡ Vol. iv. p. 178.

The question, then, in reality, is not so much between Mr. Carter and myself individually, as between that gentleman and philologists and biblical critics generally, who (I believe, with the single exception to which I have formerly alluded*,) all concur in regarding the meaning of *kópher*, in the passage in question, to be *pitch*, whatever differences of opinion may be entertained among them as to the interpretation of the word *gópher*. It seems useless, therefore, to prolong a discussion which can scarcely be attended with any satisfactory result; and I will consequently only repeat my original suggestion—in which, in fact, Mr. Carter himself coincides,—that גֹּפֶר (*gópher*) is identical with כֹּפֶר (*kópher*), whatever the correct translation and meaning of the latter word may be considered to be.

I willingly pass from this subject to the consideration of another question, which has incidentally arisen in the course of the discussion, and which, I feel persuaded, will be considered to possess more general interest. It is respecting the advance of the land upon the sea at the head of the Persian Gulf.

This subject was originally brought forward by me in a paper inserted in the Philosophical Magazine for February 1834†, (being an extract from the first volume of my work "*Origines Biblicæ*, or Researches in Primeval History," recently published,) in which I expressed the opinion, that the waters of the Persian Gulf formerly extended much further to the northward, and that the low lands at the head of that gulf have been gradually formed by the encroachment of the alluvial soil brought down and deposited by the Euphrates and Tigris and the neighbouring rivers. The conclusion thus come to was grounded upon the analogy afforded by the changes which have taken place in all countries through which great rivers take their course, confirmed by the evidence of Nearchus as to the distance, in his time, of Babylon from the sea, which was very much less than in the present day, and also by that of Pliny, who expressly states that the land did actually gain upon the sea in a most remarkable and extraordinary degree.

Mr. Carter in his last paper has disputed the correctness of my conclusion, and has, in fact, asserted the opinion, that since the time of Nearchus "the general characters of the coast have undergone but a small degree of change," and that "the encroachments on the gulf must be very unimportant." He has not, however, touched upon the *geological* portion of the argument in support of my conclusion; neither has he attempted to controvert the passage cited from Pliny: his re-

* Lond. and Edinb. Phil. Mag., vol. iv. p. 281. † Vol. iv. p. 107.

marks being confined to the discussion of the statement of Nearchus, and to the adducing of many other ancient authorities, which even, according to his own admission, contain " some discrepancies," and are not always " very explicable," and—as might naturally be predicted of them if a portion only of the changes which I contend for have taken place,—require much straining and qualifying to make them intelligible and at all applicable (as Mr. Carter contends they are,) to the present condition of the Tigris and Euphrates and the countries at the head of the Persian Gulf.

In the observations, therefore, which I have at present to make in reply to Mr. Carter, I ought perhaps to confine myself to the consideration of Nearchus's statement alone; but as my inference from the passage in Pliny has been disputed by the writer of a criticism upon my *Origines Biblicæ* contained in the number of the Quarterly Review for November 1834*, I trust that I may be permitted to add a few brief remarks upon the subject of that paper also.

We find it, then, expressly recorded by Arrian, that "from the mouth of the Euphrates the distance up the river to Babylon was stated by Nearchus to be 3300 stadia†." Nothing can be plainer than this statement, and the only point with respect to it which requires to be determined is the equivalent in English miles of the distance thus recorded. For this purpose it is not necessary to enter into any investigation of that difficult and most unsatisfactory subject of discussion, the length of the Greek stadium generally. We have here only to consider that Nearchus, in his navigation round the coast of Persia, made use of a certain standard of measurement, in which the various distances sailed by him from one station to another are registered; and as the actual localities of many of those stations appear to be absolutely determinable, so likewise ought there not to be any great difficulty in the way of determining the length of the unit of measurement used in calculating those distances.

The learned Dean Vincent, in the " Preliminary Disquisitions" to his able work " The Commerce and Navigation of the Ancients in the Indian Ocean‡," discusses at length the hypothesis of D'Anville, that the stadium employed by Nearchus is one " of 51 French toises, about 15 of which are equal to a mile Roman, 16 *to a mile English*, and 1111 to a degree§;"

* Quart. Rev., vol. lii. p. 505.

† Ἀπὸ δὲ τοῦ στόματος τοῦ Εὐφράτου ἔς τε Βαβυλῶνα πλοῦν λέγει Νέαρχος σταδίους εἶναι ἐς τρισχιλίους καὶ τριακοσίους.—*Hist. Indic.*, p. 357.

‡ 2 vols. 4to. London, 1807.

§ See Vincent's *Voyage of Nearchus*, Pref., p. xi.

and after an elaborate investigation of the subject he thus records his own opinion: "I have no hesitation in subscribing to the stadium of 51 toises assigned to the journal by D'Anville, whether it be considered as a Greek or Indian standard*;" to which he subsequently adds, "I am convinced that no other stadium known in Greece will apply to the journal of Nearchus; and if it be not a Greek stadium, I know not what measure it can be, unless it be derived from India or Arabia†."

Upon the united authority, then, of D'Anville and Vincent, the stadium of Nearchus is to be taken as one *of sixteen to a mile English*; whence it results that the 3300 stadia which Babylon, in that navigator's time, was distant from the sea, must be equal to two hundred and six miles and a half.

Strange to say, however, Dr. Vincent, in a note upon the passage from Arrian in his *Voyage of Nearchus* (p. 65), after remarking that "3300 stadia make little more than 200 miles English, [whilst] the real distance by the river is more than 400," actually offers the conjecture, in direct opposition to his own conclusion, "May not Nearchus calculate this distance by stadia of *eight* to a mile‡?" Now, it appears to me that any mode of getting over the apparent difficulty,—even

* *Comm. and Navig. of the Ancients*, vol. i. p. 66. † *Ibid.*, p. 67.

‡ In my *Origines Biblicæ* (p. 20, *note*,) I cite this note of Dr. Vincent's, and comment upon it; upon which the writer of the criticism in the Quarterly Review remarks (p. 505), "On this doubt of a most erudite geographer, so fatal to his theory, Mr. Beke observes, that 'the accuracy of the mode thus adopted by the learned translator, and by geographers generally, of reconciling apparent discrepancies in the works of ancient writers, by varying the standard of measurement, may legitimately be questioned.' Is, then, Mr. Beke prepared to show that one uniform standard was adopted by ancient writers? or to solve upon any other hypothesis the countless contradictions which are found in the writings not merely of the Greek and Roman historians, but of the geographers themselves, and which have perplexed and often baffled the D'Anvilles, the Gosselins, the Rennells, and the Mannerts of modern days?" Had the reviewer understood the ground of my objection to Dr. Vincent's conjecture, he would have spared himself the trouble of these remarks; and had he but quoted correctly my citation of Dr. Vincent's note, he would not have misled such of his readers as are not conversant with the subject, by giving them reason to imagine that there were any grounds whatever for his animadversions. I wrote, "Dr. Vincent...says 3300 stadia [of sixteen to a mile: see his Preface, p. xi.] make little more than 200 miles," &c., which passage the reviewer thus varies: "3300 stadia (of 16 to a mile) make," &c., altogether suppressing the reference made by me to Dr. Vincent's Preface, by which the inconsistency of his doubt is made apparent. Far be from me the assumption of even attempting to solve the countless contradictions to which the reviewer alludes; but yet I will venture to assert that very many of those contradictions do not exist in the text of the Greek and Latin writers themselves, but have arisen solely from the erroneous construction put upon that text by the commentators.

had it been by denying the authority of the passage in question, or by doubting the correctness of the information communicated by Nearchus,—would have been far better than the one adopted by the learned translator, which has the effect of altogether invalidating the previous conclusion (so positively expressed,) of D'Anville and himself. And, in fact, Dr. Vincent appears to have entertained a feeling of this kind, when in another place he says, "I object to all measures of this stadium taken *where Nearchus himself did not navigate*, and I hesitate about the measure of 3300 stadia from the mouth of the Euphrates to Babylon, *stated as the assertion of Nearchus**."

These objections, although in reality they cannot be maintained, are in themselves not unreasonable: let us see how they are to be met. We fortunately possess an authority, independent of Arrian, who establishes that historian's correctness, upon this subject, in all points. This authority is Pliny—or rather Juba as cited by Pliny,—who states "Euphrate navigari Babylonem e Persico mari ccccxii. mill. passuum tradunt Nearchus et Onesicritus†."

This passage from Pliny is, indeed, adduced by Mr. Carter as an authority against me, in as much as he says that Pliny "must have understood Nearchus's terms of distance better than we can." But the geographers to whom I have already referred have determined that a very different conclusion is to be drawn from Pliny's statement; it being remarked by Dr. Vincent that "M. D'Anville has shewn, that in the gulf of Persia Pliny read the same number of stadia as Arrian found in Nearchus; and that, by estimating these at eight to a mile, *he makes the distance nearly double what it is in reality*‡." It is evident, therefore, that Pliny's error is solely in the reduction of the stadia into Roman miles; and the purport of the passage in question has consequently to be thus given: "*Nearchus and Onesicritus state* the distance from the Persian Gulf *up the course of the river* (Euphrate navigari) to Babylon to be 3300 stadia."

Since then—upon the assumption, always, that D'Anville and Vincent are correct in their conclusion as to the length of the particular stadium employed by Nearchus,—the distance from Babylon to the sea by following the course of the Euphrates, in that navigator's time (B. C. 325), was only two hundred and six miles and a half, whilst in the present day it is as great as about 400 miles, it seems to me that we have no al-

* *Comm. and Navig. of the Ancients,* vol. i. p. 55.

† *Hist. Nat.*, lib. vi. cap. xxvi.

‡ *Comm. and Navig. of the Ancients,* vol. i. p. 65.

ternative but to attribute the difference between these two measurements to the gain of the land upon the sea during the intervening period of 2160 years; and as the distance in a straight line may be taken at about ¾ths of the measurement along the course of the river, the advance of the land, (as determined by this one authority,) may be computed at about 150 miles.

We have now to consider the passage from Pliny respecting Charax *; which, upon investigation, will be found to harmonize entirely with the inference which has thus been drawn from the statement of Nearchus. Two different meanings may be attributed to this passage. The first is, "that Charax when first built was ten stadia only from the shore, whilst *by the report of Juba in his time* it was 50 miles, and in Pliny's own time as much as 120 miles from the sea †." The other construction, which appears to be that of the old Italian version of Brucioli, is, "Charax was at first a port distant 10 stadia, or according to Juba 50 miles, from the sea: now [*i. e.* in Pliny's time] it is said to be 120 miles distant ‡."

If the former translation be the true one, the whole distance mentioned by Pliny must have been gained by the land between the times of Alexander and that historian; but, assuming the latter construction to be the more correct of the two, the advance of the land will be reduced nearly one half; whilst the seemingly conflicting statements as to the original distance of Charax from the sea may be reconciled by supposing that city to have been erected ten stadia only from the shore at the confluence of the Tigris and Eulæus, but at the distance of 50 miles from the sea itself. It is yet further to be considered whether Pliny, although entirely correct in his

* "Prius fuit a litore stadiis x., et maritimum etiam ipsa inde portum habuit: Juba vero prodente, l. mil. pass. Nunc abesse a litore cxx. mil. legati Arabum nostrique negotiatores qui inde venere, affirmant."—*Hist. Nat.*, lib. vi. cap. xxvii.

† The first impression made upon the mind at all times by an unqualified and indefinite expression is that it refers to the time at which it is made. Thus it was that in giving, in my *Origines Biblicæ* (p. 21.), what I conceived to be the general sense of the passage in question, I said "*in Juba's time* it was...50 miles." The writer in the Quarterly Review is, upon this, pleased to say, "Mr. Beke is, no doubt, wrong in translating *Jubâ prodente*, in Juba's time."—As may well be imagined, I never intended those words as a *translation*, and the reviewer might with as much propriety have accused me of translating *Legati Arabum...affirmant*, "in Pliny's time."

‡ "Primieramente fu marittima, lontana dal lito dieci stadij, ma secondo Juba, 50 miglia. Hora i legati degli Arabi, et i nostri mercatanti che vengono di la effermano essere lontana dal lito 120 miglia."—*Historia Naturale di C. Plinio Secondo,* tradotta per Antonio Brucioli: Venetia 1548, p. 148.

assertion of the facts themselves, may not have committed some error in the reduction into Roman miles of the actual measurements reported to him, similar to that which he is shown to have fallen into with respect to Nearchus's statement of the distance from Babylon to the Persian Gulf; in which case, the difference between the two distances of Charax from the sea in the times of Alexander and Pliny respectively, would have to be reduced yet further. But be this as it may, it is indisputable that in Pliny's time so considerable an advance of the land upon the sea had taken place since the period when Charax was first built, as to make it a subject of particular observation, and to call forth from that intelligent and observant investigator of the phænomena of nature the pointed remark, that "in no part of the world had the land gained so largely or so rapidly upon the sea*."

On the whole, then, the fact of a very considerable advance of the land at the head of the Persian Gulf must be considered as established beyond dispute; and if the distances mentioned by Nearchus and Pliny be at all near the truth, and the reduction of them into English miles be calculated even approximately only, we are still enabled to form a tolerable idea of how extensive that advance must have been. In the present state, however, of our information upon the subject, it is advisable that no hasty conclusion be come to as to the precise extent of the advance, to determine which, it will, no doubt, be necessary that extensive local investigation should take place†.

Still, if these calculations at all approach the truth, the extreme probability—not to say more—of my hypothesis, that in the earliest post-diluvian ages the low lands in the neighbourhood of Hillah were covered with water, will become yet more apparent; in which case the site of the tower of Babel, as I have suggested, must necessarily be looked for elsewhere; and it will follow also that any attempts to identify Nimrod's Babel with the Babylon of Nebuchadnezzar must be altogether unsuccessful; since, in fact, the erection of the latter city would have been *physically* impossible until a much later period,—

* "Nec ulla in parte plus aut celerius profecere terræ fluminibus invectæ." —*Hist. Nat.*, lib. vi. cap. xxvii.

† I trust that considerable information concerning the early geography of the countries under discussion will be derived from the researches of my friend Col. Chesney and the other officers now engaged on the Euphrates expedition. Before Col. Chesney's departure I had the satisfaction of acquainting him with my opinion as to the physical changes which have taken place in these countries.

until the alluvial country upon which its ruins now stand had been formed and had become fit for habitation*. The history of Babylon, therefore, cannot possibly have any connexion with that of Nimrod and his immediate successors.

Whilst upon this subject I gladly avail myself of the opportunity afforded me of correcting an error in my *Origines Biblicæ* (p. 89). I have there said that "the proper grammatical construction of the words of the text† יָצָא אַשּׁוּר *yatzá Asshúr*) is 'went forth Asshur', the word *Asshur* being the nominative or subject of the verb." In this conclusion I adopted the version of the Septuagint, Josephus, the Vulgate, and the text of our received English translation, as also the opinion of by far the greater number of scholars who have investigated the subject ‡; but, after deliberate consideration, I have no hesitation in stating, (notwithstanding this great weight of authority,) that I now entirely agree with those scholars who consider that the marginal reading of our authorized version, "he [*i. e.* Nimrod,] went out into Assyria," is to be preferred. Mr. Carter adopts this latter reading; and a writer in the first number of Cochrane's Foreign Quarterly Review (p. 82), inculpates me for advocating the opinion which I here relinquish. In consequence of this correction there is no necessity for imagining (as, under the influence of the same error, I have done, in *Orig. Bibl.*, pp. 24—26,) that after the Dispersion from Babel, Nimrod founded in the land of Shinar a *second* city, of the same name: on the contrary, the Scriptural narrative, according to the interpretation which I now consider to be the correct one, expressly tells us that *he went out of that land* into Assyria, where he founded Nineveh and the other cities which are named in the text.

I am, Gentlemen,

Your obedient servant,

London, April 30, 1835. CHARLES T. BEKE.

* In my *Origines Biblicæ* (p. 66), I have given my reasons for placing the site of the tower of Babel in the north-western portion of Mesopotamia. In the same work (p. 259, *note*,) I have hinted at the possibility of the ruins at Hillah not being even those of Nebuchadnezzar's Babylon; and I have since suggested to Col. Chesney that the actual site of that city may be some thirty or forty miles to the north-westward of Hillah; in fact, not upon the present course of the Euphrates, but upon what is represented in the maps as having been an ancient branch of that river.

† Gen. x. 11.

‡ See upon this point Dr. Russell's *Connection of Sacred and Profane History*, vol. ii. pp. 2 and 43.

LXIII. *Remarks on some curious Facts respecting Vision described in the Lond. and Edinb. Phil. Mag. for* 1834. *By* LEWIS TONNA.

To the Editors of the Philosophical Magazine.

Gentlemen,

I HAVE just seen a letter from K. relating to "some curious facts respecting vision," which appeared in your Journal for November 1834. I will not trespass further on your pages than to state that for the last six years a similar difference in power of vision has existed in my eyes. By altering the axis of vision of the two eyes, and thus producing a double image of any object, the image offered by the left eye is even less than half the size of the one presented by the right eye. There is also a slight indistinctness in the image, independently of the reduction in size. This affection came on gradually, and was not produced by any disease, either constitutional or local, that I am aware of. Whether I am right in attributing this fact to an undue diminution of convexity in the left eye, similar to that habitual to old age, I know not.

In a sound state of vision, it is doubtless by an habitual and imperceptible exertion of the brain that the images offered by the two eyes are made to coincide and produce the perception of one single image.

In my case the impossibility of producing a coincidence of images of different magnitudes causes a general indistinctness of vision, and I can see objects clearer and better defined with the right eye alone than with both eyes; but on applying a convex lens of great power (which I always use,) to the left eye, the distinctness is restored, and all colours immediately become more vivid. I should be glad to hear the opinion of persons better able than myself to judge of this phænomenon, and whether the use of a lens is judicious. The expansion and contraction of the pupil on sudden exposure to changes of intensity of light, is more sluggish in the left or diseased eye than in the right one. This is the only external difference.

I am, Gentlemen, yours, &c.,

LEWIS TONNA.

United Service Museum, London,
April 16, 1835.

*** We may now state that the author of the paper signed "K." above referred to, was the late lamented Capt. Kater, in whom the disease of vision it describes seems to have been the precursor of death. It was probably almost the last contribution to science of that distinguished natural philosopher.—EDIT.

LXIV. *Experimental Researches in Electricity.—Eighth Series.* By MICHAEL FARADAY, *D.C.L. F.R.S. Fullerian Prof. Chem. Royal Institution, Corr. Memb. Royal and Imp. Acadd. of Sciences, Paris, Petersburgh, Florence, Copenhagen, Berlin, &c. &c.*

[Continued from p. 348, and concluded.]

¶ v. *General Remarks on the active Voltaic Battery.*

1034. WHEN the ordinary voltaic battery is brought into action, its very activity produces certain effects, which re-act upon it, and cause serious deterioration of its power. These render it an exceedingly inconstant instrument as to the *quantity* of effect which it is capable of producing. They are already, in part, known and understood; but as their importance, and that of certain other coincident results, will be more evident by reference to the principles and experiments already stated and described, I have thought it would be useful, in this investigation of the voltaic pile, to notice them briefly here.

1035. When the battery is in action, it causes such substances to be formed and arrayed in contact with the plates as very much weaken its power, or even tend to produce a counter current. They are considered by Sir Humphry Davy as sufficient to account for the phænomena of Ritter's secondary piles, and also for the effects observed by M. A. De la Rive with interposed platina plates *.

1036. I have already referred to this consequence (1003.), as capable, in some cases, of lowering the force of the current to one eighth or one tenth of what it was at the first moment, and have met with instances in which its interference was very great. In an experiment in which one voltaic pair and one interposed platina plate were used with dilute sulphuric acid in the cells (fig. 31.), the wires of communication were so arranged, that the end of that marked 3 could be placed at pleasure upon paper moistened in the solution of iodide of potassium at *x*, or directly upon the platina plate there. If, after an interval during which the circuit had not been complete, the wire 3 were placed upon the paper, there was evidence of a current, decomposition ensued, and the galvanometer was affected. If the wire 3 were made to touch the metal of *p*, a comparatively strong sudden current was produced, affecting the galvanometer, but lasting only for a moment; the effect at the galvanometer ceased, and if the wire 3 were placed on the paper at *x*, no signs of decomposition occurred. On raising the wire 3, and breaking the circuit

* Philosophical Transactions, 1826, p. 413. [or Phil. Mag. and Annals, N.S., vol. i. p. 193.—EDIT.]

altogether for a while, the apparatus resumed its first power, requiring, however, from five to ten minutes for this purpose; and then, as before, on making contact between 3 and *p*, there was again a momentary current, and immediately all the effects apparently ceased.

1037. This effect I was ultimately able to refer to the state of the film of fluid in contact with the zinc plate in cell i. The acid of that film is instantly neutralized by the oxide formed; the oxidation of the zinc cannot, of course, go on with the same facility as before; and the chemical action being thus interrupted, the voltaic action diminishes with it. The time of the rest was required for the diffusion of the liquid, and its replacement by other acid. From the serious influence of this cause in experiments with single pairs of plates of different metals, in which I was at one time engaged, and the extreme care required to avoid it, I cannot help feeling a strong suspicion that it interferes more frequently and extensively than experimenters are aware of, and therefore direct their attention to it.

1038. In considering the effect in delicate experiments of this source of irregularity of action in the voltaic apparatus, it must be remembered that it is only that very small portion of matter which is directly in contact with the oxidizable metal which has to be considered with reference to the change of its nature; and this portion is not very readily displaced from its position upon the surface of the metal (582. 605.), especially if that metal be rough and irregular. In illustration of this effect, I will quote a remarkable experiment. A burnished platina plate (569.) was put into hot strong sulphuric acid for an instant only: it was then put into distilled water, moved about in it, taken out, and wiped dry: it was put into a second portion of distilled water, moved about in it, and again wiped: it was put into a third portion of distilled water, in which it was moved about for nearly eight seconds; it was then, without wiping, put into a fourth portion of distilled water, where it was allowed to remain five minutes. The two latter portions of water were then tested for sulphuric acid; the third gave no sensible appearance of that substance, but the fourth gave indications which were not merely evident, but abundant, for the circumstances under which it had been introduced. The result sufficiently shows with what difficulty that portion of the substance which is in *contact* with the metal leaves it; and as the contact of the fluid formed against the plate in the voltaic circuit must be as intimate and as perfect as possible, it is easy to see how quickly and greatly it must vary from the general fluid in the

cells, and how influential in diminishing the force of the battery this effect must be.

1039. In the ordinary voltaic pile, the influence of this effect will occur in all variety of degrees. The extremities of a trough of twenty pairs of plates of Wollaston's construction were connected with the volta-electrometer, fig. 11. (711.), of the Seventh Series of these Researches*, and after five minutes the number of bubbles of gas issuing from the extremity of the tube, in consequence of the decomposition of the water, [was] noted. Without moving the plates, the acid between the copper and zinc was agitated by the introduction of a feather. The bubbles were immediately evolved more rapidly, above twice the number being produced in the same portion of time as before. In this instance it is very evident that agitation by a feather must have been a very imperfect mode of restoring the acid in the cells against the plates towards its first equal condition; and yet imperfect as the means were, they more than doubled the power of the battery. The first effect of a battery, which is known to be so superior to the action which the battery can sustain, is almost entirely due to the favourable condition of the acid in contact with the plates.

1040. A *second* cause of diminution in the force of the voltaic battery, consequent upon its own action, is that extraordinary state of the surfaces of the metals (969.) which was first described, I believe, by Ritter †, to which he refers the powers of his secondary piles, and which has been so well experimented upon by Marianini, and also by A. De la Rive. If the apparatus, fig. 31. (1036.), be left in action for an hour or two, with the wire 3 in contact with the plate *p*, so as to allow a free passage for the current, then, though the contact be broken for ten or twelve minutes, still, upon its renewal, only a feeble current will pass, not at all equal in force to what might be expected. Further, if P^1 and P^2 be connected by a metal wire, a powerful momentary current will pass from P^2 to P^1 through the acid, and therefore in the reverse direction to that produced by the action of the zinc in the arrangement; and after this has happened, the general current can pass through the whole of the system as at first, but by its passage again restores the plates P^2 and P^1 into the former opposing condition. This, generally, is the fact described by Ritter, Marianini, and De la Rive. It has great opposing influence on the action of a pile, especially if the latter consist of but a small number of alternations, and has to pass its current through many interpositions. It varies with the solution

[* Lond. and Edinb. Phil. Mag., 1834.—Edit.]

† *Journal de Physique*, lvii. p. 349.

in which the interposed plates are immersed, with the intensity of the current, the strength of the pile, the time of action, and especially with accidental discharges of the plates by inadvertent contacts or reversions of the plates during experiments, and must be carefully watched in every endeavour to trace the source, strength and variations of the voltaic current. Its effect was avoided in the experiments already described (1036. &c.), by making contact between the plates P^1 and P^2 before the effect dependent upon the state of the solution in contact with the zinc plate was observed, and by other precautions.

1041. When an apparatus like fig. 26. (1017.) with several platina plates was used, being connected with a battery able to force a current through them, the power which they acquired, of producing a reverse current, was very considerable.

1042. *Weak and exhausted charges* should never be used at the same time with *strong and fresh ones* in the different cells of a trough, or the different troughs of a battery: the fluid in all the cells should be alike, else the plates in the weaker cells, in place of assisting, retard the passage of the electricity generated in, and transmitted across, the stronger cells. Each zinc plate so circumstanced has to be assisted in decomposing power before the whole current can pass between it and the liquid. So that, if in a battery of fifty pairs of plates, ten of the cells contain a weaker charge than the others, it is as if ten decomposing plates were opposed to the transit of the current of forty pairs of generating plates (1031.). Hence a serious loss of force, and hence the reason why, if the ten pairs of plates were removed, the remaining forty pairs would be much more powerful than the whole fifty.

1043. Five similar troughs, of ten pairs of plates each, were prepared, four of them with a good uniform charge of acid, and the fifth with the partially neutralized acid of a used battery. Being arranged in right order, and connected with a volta-electrometer (711.), the whole fifty pairs of plates yielded 1·1 cubic inch of oxygen and hydrogen in one minute; but on moving one of the connecting wires so that only the four well-charged troughs should be included in the circuit, they produced with the same volta-electrometer 8·4 cubical inches of gas in the same time. Nearly seven eighths of the power of the four troughs had been lost, therefore, by their association with the fifth trough.

1044. The same battery of fifty pairs of plates, after being thus used, was connected with a volta-electrometer (711.), so that by quickly shifting the wires of communication, the current of the whole of the battery, or of any portion of it, could

be made to pass through the instrument for given portions of time in succession. The whole of the battery evolved 0·9 of a cubic inch of oxygen and hydrogen in half a minute; the forty plates evolved 4·6 cubic inches in the same time, the whole then evolved 1 cubic inch in the half minute; the ten weakly charged evolved 0·4 of a cubic inch in the time given: and finally the whole evolved 1·15 cubic inch in the standard time. The order of the observations was that given: the results sufficiently show the extremely injurious effect produced by the mixture of strong and weak charges in the same battery*.

1045. In the same manner associations of *strong and weak* pairs of plates should be carefully avoided. A pair of copper and platina plates arranged in *accordance* with a pair of zinc and platina plates in dilute sulphuric acid, were found to stop the action of the latter, or even of two pairs of the latter, as effectually almost as an interposed plate of platina (1011.), or as if the copper itself had been platina. It, in fact, became an interposed decomposing plate, and therefore a retarding instead of an assisting pair.

1046. The *reversal*, by accident or otherwise, of the plates in a battery has an exceedingly injurious effect. It is not merely the counter action of the current which the reversed plates can produce, but their effect also in retarding even as indifferent plates, and requiring decomposition to be effected upon their surface, in *accordance* with the course of the current, before the latter can pass. They oppose the current, therefore, in the first place, as platina interposed plates would do (1011—1018.); and to this they add a force of opposition as counter-voltaic plates. I find that, in a series of four pairs of zinc and platina plates in dilute sulphuric acid, if one pair be reversed, it very nearly neutralizes the power of the whole.

1047. There are many other causes of reaction, retardation, and irregularity in the voltaic battery. Amongst them is the not unusual one of precipitation of copper upon the zinc in the cells, the injurious effect of which has before been adverted to (1006.). But their interest is not perhaps sufficient to justify any increase of the length of this paper, which is rather intended to be an investigation of the theory of the voltaic pile than a particular account of its practical application.

Note.—Many of the views and experiments in this Series of my Experimental Researches will be seen at once to be cor-

* The gradual increase in the action of the whole fifty pairs of plates was due to the elevation of temperature in the weakly charged trough by the passage of the current, in consequence of which the exciting energies of the fluid within were increased.

rections and extensions of the theory of electro-chemical decomposition, given in the Fifth and Seventh Series of these Researches. The expressions I would now alter are those which relate to the independence of the evolved elements of the poles or electrodes, and the reference of their evolution to powers entirely internal (524. 537. 661.). The present paper fully shows my present views; and I would refer to paragraphs 891. 904. 910. 917. 918. 947. 963. 1007. 1031. &c., as stating what they are. I hope this note will be considered as sufficient in the way of correction at present; for I would rather defer revising the whole theory of electro-chemical decomposition until I can obtain clearer views of the way in which the power under consideration can appear at one time as associated with particles giving them their chemical attraction, and at another as free electricity (493. 957.).—M. F.

Royal Institution, March 31, 1834.

LXV. *Notice of some Experiments which show a repulsive Action between heated Surfaces and certain pulverulent Bodies. By* R. Addams, *Esq., Lecturer on Chemistry and Natural Philosophy*.*

THAT caloric possesses a repellent force is assumed from the effects it produces upon matter in general: but there are those who do not allow that we have any unequivocal evidence of calorific repulsion between independent bodies, such, for example, as two separate masses of heated iron; indeed, the question whether caloric does not act repulsively at sensible distances, has recently been made the subject of experimental investigation by the Rev. Professor Powell†, who, in the Philosophical Transactions for the last year, has given an account of an elegant and refined mode of testing the repulsion between two heated lenticular masses of glass.

The following description of some experiments which seem to bear upon the question may not, therefore, be unacceptable to those who are interested in this branch of inquiry.

Exp. 1. A small quantity of silica (prepared by precipitation from its alkaline solution) was heated upon a platinum capsule: when the heat—that from a spirit-lamp—had acted for a second or two, the powder moved, by the least motion of the capsule, as if it were floating upon a liquid, having a mobility almost equal to that of mercury. The fric-

* Communicated by the Author.

† Lond. and Edinb. Phil. Mag., vol. vi. p. 58.

tion between the metal and silica was so trifling that the latter would often remain stationary, whilst the former slid beneath it; and when the capsule was moved, by the hand, circularly in one direction, the powder would revolve the contrary way. The effect ceases almost instantly by a removal from the lamp, and is renewed as often as it is reheated. Whilst subjected to the flame of the lamp, if touched with a cold body, as a metallic wire or glass rod, it would *sometimes* lose its peculiar freedom to glide about, and then rest upon the platinum vessel sluggish and immoveable otherwise than with the vessel itself.

Exp. 2. Supposing it possible that moisture might interfere, I introduced another portion of silica into a glass flask, mounted with a stop-cock, and heated it to a temperature of from 300° to 500°, in which state it was kept for a week with the valve closed. After the first action of the heat to expel a part of the air, it still continued to exhibit the same phænomenon as before in the open vessel. The air was additionally rarified by an air-pump, but with no alteration in the behavour of the powder.

Exp. 3. Magnesia, peroxide of copper, sesquioxide of lead, peroxide of cobalt, oxide of nickel, peroxide of manganese, and smalt, were successively heated as in Exp. 1, and with correspondent results.

On the other hand, oxide of chromium, litharge, and alumina afforded little or no evidence of such peculiarity.

Remembering Dr. Faraday's experiment "on the electric powers of oxalate of lime*," I subjected that compound to a similar trial; and obtained evidence of the same kind of motion as before (1.), yet in a less degree than with silica and the substances named in No. 3. from magnesia to smalt inclusive.

The powders were more or less in an electric state, but this (the electricity,) I regard as an accompaniment, and not as the cause of the free motion of the powders upon the metal; for touching the metal with good conductors of electricity made no alteration save that which could fairly be assigned to the cooling effect upon the platinum or glass capsules, both having been employed. Also by insulating the platinum no difference was noticed.

In Dr. Faraday's experiment before referred to, the oxalate of lime was electrified, positively, by stirring it with a rod or spatula, whereas the diminished friction or contact between the bodies concerned in the experiments now described took place without stirring or previous agitation.

* Journal of the Royal Institution, vol. xix. p. 338.

The quantities of the powders which I have hitherto employed have been too small, (not exceeding 30 or 40 grains,) to decide upon their electrical states in a satisfactory manner.

Before I conclude the present communication, I will advert to a simple experiment, which is familiar to many, I have no doubt, and which bears upon the subject under consideration.

Thus: take up a small portion of tallow at the end of a wire; hold the latter inclined to the horizon and with the hand uppermost; thrust the tallow into the flame of a candle, and it will be seen to react from the heat and run up the wire, in a melted state, to the distance of an inch or more. Professor Stevelly alluded to this experiment in reference to the repulsive agency of heat, at the meeting of the British Association in Edinburgh.

Kensington, January 6, 1835.

LXVI. *On Water as a Constituent of Salts. In the Case of Sulphates.* By Thomas Graham, *F.R.S.E., Andersonian Professor of Chemistry and Vice-President of the Philosophical Society of Glasgow.*

[Continued from p. 334, and concluded.]

Sulphate of Zinc with Sulphate of Soda: $\dot{Zn}\dddot{S}(\dot{Na}\dddot{S})+\dot{H}^4$. *Sulphate of Zinc and Soda.*

THIS salt, I believe, has not hitherto been described. I failed in attempting to form it, by dissolving together sulphate of zinc and sulphate of soda in atomic proportions: the salts uniformly crystallized apart, either in cold or in warm weather. Each of the salts was also added in excess to the other, but with no better effect. It appears, then, that sulphate of soda does not displace the saline water of sulphate of zinc, so easily as sulphate of potash does. But the desired salt was obtained by a process of double decomposition, suggested from consideration of the relations of the sulphates. Solutions of bisulphate of soda, and of sulphate of zinc, were mixed together in atomic proportions, from which the sulphate of zinc and soda separated in a gradual manner in the course of a day or two, leaving sulphuric acid in solution.

Sulphate of zinc with saline water,	yield	Sulphate of zinc with sulphate of soda.
Sulphate of water with sulphate of soda,		Sulphate of water with saline water.

This salt is deposited in distinct tabular crystals, of a pecu-

liar form, which are often associated in tufts; and is best obtained by evaporating the mixed solutions over sulphuric acid without heat. It cannot be redissolved in pure water, without undergoing decomposition, which accounts for the impossibility of forming it by the direct process. The crystals contain four atoms of water, and are about as deliquescent as nitrate of soda, in a damp atmosphere. The anhydrous salt undergoes fusion, like all the other double sulphates, at an incipient red heat, without the evolution of acid fumes. The fused salt solidifies, on cooling, into a white and opake mass.

Sulphate of Copper with Saline Water: $\dot{C}u\dddot{S}\dot{H} + \dot{H}^4$. *Sulphate of Copper.*

The common blue rhomboidal crystals of sulphate of copper contain five atoms of water, four of which are readily expelled, by drying the salt in air at 212°; by which treatment the salt loses its blue colour, and becomes white, with a dirty shade of green. The sulphate of copper with one atom of water was also obtained in a crystallized state by Dr. Thomson, and called by him green sulphate of copper. Dried over sulphuric acid *in vacuo* for seven days, when it had ceased to lose, at a temperature between 65° and 74°, the common hydrated salt retained 21·67 parts water to 100 anhydrous salt, which is somewhat under two atomic proportions of water, namely 22·57 parts. At a temperature between 430° and 470°, the sulphate of copper loses its fifth, or saline, atom of water, and is found in the state of a powder, which is white without any shade of colour. When a few drops of water are thrown upon anhydrous sulphate of copper, it slakes and becomes blue, and so much heat is evolved as to occasion the ebullition of the water. In one case the temperature was observed to rise to 276°. This arises from the resumption of saline water by the salt.

Sulphate of Copper with Sulphate of Potash: $\dot{C}u\dddot{S}(\dot{K}\dddot{S}) + \dot{H}^6$. *Sulphate of Copper and Potash.*

This salt may be formed by mixing sulphate of copper with either sulphate or bisulphate of potash, in atomic proportions. Dried in the open air, it loses six atoms water, and becomes quite anhydrous at a temperature not exceeding 270° Fahr. The following Table of the composition of this hydrated salt in different circumstances, illustrates three facts,—that the salt has a disposition to retain two atoms of water when dried at 212° in open air,—that a greater portion of water of crystallization is withdrawn from the salt by drying it over sulphuric

acid *in vacuo*, without artificial heat, than by drying it at 212° under the atmospheric pressure, and that the mechanical water retained by the crystals of this salt may exceed 3 per cent. of their weight.

	Anhydrous Salt.	Water.	Anhydrous Salt.	Water.
Dried on water-bath at 212°, for three days, or till it ceased to lose weight	19·6	2·21	100	11·27
Dried on nitre-bath at 238°, for three days	22·06	2·37	100	10·74
Dried *in vacuo* over sulphuric acid for seven days, or till it ceased to lose weight; therm. from 65° to 74° ...	22·97	1·61	100	7·09
Crystals pounded, and slightly dried at 80°, so as not to injure the lustre of an entire crystal	13·94	3·4	100	32·25
Same crystals not deprived of mechanical water by the above treatment	23·79	8·64	100	36·22
Composition of sulphate of copper and potash with two atoms of water (by theory)	...	...	100	10·77
Composition of do. with six atoms of water (by theory)	...	...	100	32·33

I have confirmed the observation of Berzelius, that a concentrated solution of this salt, when boiled, deposits an insoluble subsalt, containing sulphate of potash, but which is decomposed by washing, and cannot be had in a proper state for analysis. But the crystals of the double salt are quite soluble after being heated to 212°, so that they do not undergo the same change as their solution does at that temperature.

This double salt retains its blue colour after being fused at a red heat and cooled, and does not become white like the sulphate of copper. Indeed it appears, that, to be coloured, the salts of the oxide of copper require the addition of some other constituent, such as saline water, sulphate of potash, or ammonia. Hence, if the absolute sulphate of copper could be obtained in a crystallized state, it would be a colourless salt.

Sulphate of Copper with Sulphate of Soda: $\dot{\mathrm{Cu}}\dddot{\mathrm{S}}(\dot{\mathrm{Na}}\dddot{\mathrm{S}}) + \dot{\mathrm{H}}^2$. *Sulphate of Copper and Soda.*

Like the other double salts of sulphate of soda, this salt cannot be formed directly, being decomposed by water. Even when it is attempted to form it by double decomposition from the bisulphate of soda, in general a large quantity of sulphate of soda and of sulphate of copper are separately deposited before the double salt appears. It is then deposited in a crust, consisting of small but distinct crystals, which are slightly deliquescent, and appear to contain two proportions of water. This salt is easily made anhydrous, and thereafter fuses at an incipient red heat without loss of acid, and remains of a blue colour when cool. The fused salt does not split into thin scales in the progress of cooling, as the corresponding sulphate of copper and potash does.

Sulphate of Manganese with Saline Water: $\dot{\mathrm{Mn}}\dddot{\mathrm{S}}\dot{\mathrm{H}} + \dot{\mathrm{H}}^4$. *Sulphate of Manganese.*

The water in this salt was found to be reduced from five atomic proportions to little more than one, by drying the crystals in open air at 238°, while one entire atomic proportion was retained at 410°. Flesh-coloured crystals, dried *in vacuo* in warm summer weather, without artificial heat, lost somewhat more than three proportions of water.

	Anhydrous Salt.	Water.	Anhydrous Salt.	Water.
Flesh-coloured crystals of salt	28·42	17·07	100	60·06
Do. dried at 238°...............	21·53	2·92	100	13·05
A portion of last, afterwards dried for one hour between 380° and 410°...............	9·54	1·12	100	11·74
A portion of same, dried for one hour between 415° and 468°...........................	10·90	0·56	100	5·14
Crystals dried for nine days *in vacuo* over sulphuric acid, therm. 64° to 72°, but had lost nothing the last two days	8·62	11	100	20·88
Composition of sulphate of manganese with one atom of water (by theory).........	...	...	10	11·88
Composition of do. with five atoms of water..............	...	...	100	59·4

A crystalline crust of sulphate of manganese, deposited from a warm solution, was found to contain three atoms of water. It is likewise known to be deposited from a boiling solution with only one atom of water, namely, the saline atom. We have, therefore, sulphates of this class with no water of crystallization, and with two, four, and six atoms.

The sulphate of manganese and potash did not crystallize on mixing the solutions of its constituents. The sulphate of manganese and soda was obtained in analogous circumstances with the sulphate of copper and soda, but was not examined.

Sulphate of Iron with Saline Water: $\dot{\mathrm{Fe}}\dddot{\mathrm{S}}\dot{\mathrm{H}}+\dot{\mathrm{H}}^6$. *Sulphate of Iron.*

Of the seven atomic proportions of water which the crystals contain, 5·48 proportions were lost *in vacuo* over sulphuric acid; and six proportions at 238°, and probably at lower temperatures. The saline atom of water is retained by this salt at so high a temperature as 535°. But the salt can be made perfectly anhydrous, with proper caution, without appreciable loss of acid.

Sulphate of Iron with Sulphate of Potash: $\dot{\mathrm{Fe}}\dddot{\mathrm{S}}(\dot{\mathrm{K}}\dddot{\mathrm{S}})+\dot{\mathrm{H}}^6$. *Sulphate of Iron and Potash.*

A specimen of this salt was made anhydrous by a sandbath heat, which was found not to affect the saline atom of water of the preceding compound.

Sulphate of nickel was found to correspond closely with sulphate of iron in the temperatures at which it lost its water of crystallization, and also its saline water. And in the case of both of the compounds of these salts with sulphate of potash, a considerably higher temperature was required to render them perfectly anhydrous, than in the case of the corresponding double salt of zinc.

Sulphate of Magnesia with Saline Water: $\dot{\mathrm{Mg}}\dddot{\mathrm{S}}\dot{\mathrm{H}}+\dot{\mathrm{H}}^6$. *Sulphate of Magnesia.*

One atom of water is retained by sulphate of magnesia at 460°, but the other six are not entirely expelled under 270° in open air. Indeed this sulphate is remarkable for a disposition to retain two atoms of water, in which respect it resembles the sulphate of lime. Dried at 212° in open air, the crystals of sulphate of magnesia were found in several experiments to retain somewhat more than two atomic proportions of water. When dried at the same temperature *in vacuo* over sulphuric acid, the water was reduced to two proportions. Crystals

placed over sulphuric acid *in vacuo*, without heat, were found to retain only two and a quarter atomic proportions of water.

	Anhydrous Salt.	Water	Anhydrous Salt.	Water.
Crystallized salt, dried *in vacuo* at 70° for six days, or till it ceased to lose	12·34	4·13	100	33·46
Do. *in vacuo* at 212°	21·8	6·24	100	28·62
Do. heated between 410° and 460° for one hour, being previously dried at 238° ...	4·9	0·74	100	15·1
Relative composition of the anhydrous salt with one atom of water (by theory)	...	...	100	14·81

The sulphate of magnesia and ammonia lost its six atoms of water of crystallization and became anhydrous, when exposed to a temperature not exceeding 270°, for one hour, having previously been dried at 212°. It retained of course the atom of water which is essential to the ammoniacal salts. A somewhat higher temperature was required to deprive the sulphate of magnesia and potash of its whole water of crystallization.

Hydrated Sulphate of Lime: $\dot{C}a\dddot{S}\dot{H}+\dot{H}$.

The only crystalline hydrate of sulphate of lime, which is known, contains two atoms of water. It occurs native in [the form of] gypsum and selenite. Pounded selenite loses little or nothing in the open air at 212°. Water begins to escape at a temperature not much higher, but is not completely expelled by any degree of heat under 270°. That hydrated sulphate of lime may contain an atom of saline water, is indicated by the existence of a double salt of sulphate of lime with sulphate of soda, constituting the mineral Glauberite. I succeeded in obtaining a definite compound of sulphate of lime with one atom of water, by drying pounded selenite, at 212°, *in vacuo* over sulphuric acid*. The salt which had been so dried at 212° did not form a coherent mass, like stucco, when made into a paste with water. The affinity of sulphate of lime for the saline atom of water appears to be feeble, as the salt can be made quite anhydrous under 300°; and consequently the sul-

* It has subsequently been observed, that the water is reduced under one atomic proportion, by a protracted exposure to the same temperature.

phate of lime has much less disposition to form double salts than the sulphates of magnesia, zinc, &c.

	Anhydrous Salt.	Water.	Anhydrous Salt.	Water.
Selenite, dried for ten days in open air at 212°	17·07	4·27	100	25·01
Do. dried *in vacuo* at 212°......	17·61	3·04	100	14·72
Sulphate of lime with one atom of water (by theory)	...	...	100	13·13
Do. with two atoms of water (by theory)	...	...	100	26·26

In drying gypsum, to make plaster of Paris, a third or a fourth of the water of the salt is allowed to remain, by which it sets more strongly. But the salt may be made quite anhydrous, I find, and yet retain the power of recombining with two atoms of water, if dried at a temperature not exceeding 270° Fahr.; although the hydrate which results on slaking in the last case is rather pulverulent. When gypsum has been dried at a higher temperature, as at 300° or 400° Fahr., it refuses entirely to combine with water, and is technically called *burnt stucco.* The anhydrous sulphate of lime which occurs in nature exhibits the same indifference to water. In anhydrite we have, I believe, the true or absolute sulphate of lime in a crystallized state. The body which results from exposing hydrated sulphate of lime to 270°, although composed of nothing but sulphuric acid and lime, should be viewed as the *debris* of the hydrated sulphate of lime, and not confounded with the absolute sulphate of lime, which last has no disposition to combine with water. The first, which we may call "anhydrous gypsum," is an *imperfect* body. We know sulphate of lime in four states, which may be expressed symbolically as follows:

Gypsum .... $\dot{\mathrm{Ca}}\dddot{\mathrm{S}}\dot{\mathrm{H}}+\dot{\mathrm{H}}$

Gypsum dried at 212° .... $\dot{\mathrm{Ca}}\dddot{\mathrm{S}}\dot{\mathrm{H}}$

Anhydrous gypsum (dried at 270°) $\dot{\mathrm{Ca}}\dddot{\mathrm{S}}-$

Anhydrite .... $\dot{\mathrm{Ca}}\dddot{\mathrm{S}}$

Here we distinguish the imperfect body, anhydrous gypsum, from anhydrite, by placing the *minus* sign after the former. In the same manner, concentrated sulphuric acid, or oil of vitriol, may be represented by $\dot{\mathrm{H}}\dddot{\mathrm{S}}-$; anhydrous sulphate of

magnesia, sulphate of zinc, &c. by $\dot{\mathrm{M}}\mathrm{g}\dddot{\mathrm{S}}$—, $\dot{\mathrm{Z}}\mathrm{n}\dddot{\mathrm{S}}$—, &c.; the absolute sulphates of water, magnesia, zinc, &c., $\dot{\mathrm{H}}\dddot{\mathrm{S}}$, $\dot{\mathrm{M}}\mathrm{g}\dddot{\mathrm{S}}$, $\dot{\mathrm{Z}}\mathrm{n}\dddot{\mathrm{S}}$, &c., being unknown to us.

The view which is given in this paper of the constitution of the sulphates, must not be hastily generalized and applied to other classes of salts. From investigations not yet completed, I am satisfied that each class of salts has its peculiarities, which must be studied before the law of the class can be laid down.

LXVII. *Notice of the Arrival of Twenty-six of the Summer Birds of Passage in the Neighbourhood of Carlisle, during the Spring of* 1834, *to which are added a few Observations on some of the scarcer Birds that have been obtained in the same Vicinity from the* 10*th of November* 1833 *to the* 10*th of November* 1834. *By* A Correspondent.*

No.	English Specific Names.	Latin Generic and Specific Names.	When first observed.		No.
1	Quail	Coturnix vulgaris	April	20	6
2	Swallow	Hirundo rustica	——	4	35
3	House Martin	——— urbica	——	28	36
4	Sand Martin	——— riparia	——	4	36
5	Swift	Cypselus Apus	——	27	37
6	Goatsucker	Caprimulgus europæus	May	3	38
7	Pied Flycatcher	Muscicapa Atricapilla	April	25	41
8	Spotted Flycatcher	——— Grisola	May	3	42
9	Ring Ouzel	Turdus torquatus	April	5	49
10	Wheatear	Saxicola Œnanthe	——	8	53
11	Whinchat	——— Rubetra	——	15	54
12	Redstart	Sylvia Phœnicurus	——	17	57
13	Grasshopper Warbler	Curruca Locustella	——	7	58
14	Sedge Warbler	——— salicaria	——	30	59
15	Greater Pettychaps	——— hortensis	May	1	62
16	Wood Wren	——— Sibilatrix	——	3	63
17	Blackcap	——— Atricapilla	April	14	64
18	Whitethroat	——— Sylvia	——	30	66
19	Yellow Wren	Regulus Trochilus	——	16	70
20	Yellow Wagtail	Motacilla flava	——	5	75
21	Field Lark, or Titling	Anthus trivialis	——	18	78
22	Cuckoo	Cuculus canorus	——	17	121
23	Wryneck	Yunx Torquilla	——	15	125
24	Corncrake, or Land-Rail	Ortygometra Crex	——	10	129
25	Dottrel	Charadrius Morinellus	May	11	164
26	Common Tern	Sterna Hirundo	——	9	235

[*Obs.*—The figures contained in the column on the right in the above

* Communicated by the Author.

Quail.—Two specimens of this bird were killed in this district during the winter months of 1833-4, namely, one near Druinbrugh on the 18th of December 1833, the other in the vicinity of Wigton on the 6th of November 1834; both were males.

79. *Crossbill* (*Loxia curvirostra*).—A small flock of Crossbills were accidentally observed in a fir-plantation not far from the village of Castle Carrock on the 26th of February, eight of which were obtained. This bird is of very rare occurrence in this neighbourhood, yet we have some reason to believe that a few visit the hilly districts in this county almost annually, at least more frequently than is generally supposed.

138. *Dusky Sandpiper* or *Spotted Snipe* (*Totanus fuscus*).—A young bird of this species was occasionally seen on Rockcliff Marsh about the middle of August; it, however, escaped, although pursued for several days.

140. *Green Sandpiper* (*Totanus ochropus*). — Two Green Sandpipers were shot in the month of August; the first on the 7th, on the banks of the river Esk, near Floris town; the second on the 10th, a short distance from the river Petril, in the vicinity of Newbiggin Hall: one or two others were seen.

152. *Pygmy Curlew* (*Tringa subarquata*).—A pretty large flock of Pygmy Curlews frequented the Rockcliff Marsh during the latter end of September and the beginning of October. All the specimens killed that came under our observation were young birds of the year. A few years ago this species was considered one of the rarest British visitants, but latterly it has been annually met with in various parts of England, as well as in Ireland.

159. *Common Turnstone* (*Strepsilas Interpres*). — On the 13th of August six Turnstones were seen on the hilly moors in the parish of Bewcastle, a very considerable distance from the coast.

161. *Grey Plover* (*Squalarola cinerea*).—Grey Plovers in pretty considerable numbers visited the coast in this vicinity during the latter end of September and the beginning of October. The few that were obtained were all young birds. On referring to the few remarks we made on this species in our communication for the year 1830, it will be seen that the

Table, as well as those affixed to the species not included in it, refer to the numbers in Fleming's History of British Animals, which we have inserted, in order that any reader who may wish to have a description or to see the various synonyms of any of the birds alluded to in this paper may find the species at once, should he possess or have an opportunity of consulting that very useful publication.]

Grey Plover is only occasionally met with in this part of the county*.

180. *Long-tailed Duck* (*Clangula vulgaris*).—The only specimen of this species that has been detected in this vicinity, to the best of our knowledge, was killed about the 1st of November. It was a very young bird, but most fortunately proved to be a male, so that we had the gratification of examining the very singular trachea of this species, which Montagu has figured with great accuracy in the Supplement to the Ornithological Dictionary.

204. *Razor Bill* (*Alca Torda*).—A specimen of this bird was killed on the 1st of January, in a rather singular locality, namely, on the moors in the parish of Bewcastle, at no great distance from the situation where the Turnstones above alluded to were seen. This bird was, no doubt, on its passage either to or from the western coast.

206. *Crested Grebe* (*Podiceps cristatus*).—An old male of this species was obtained on Brugh Marsh on the 3rd of October. Although young birds are now and then met with, this is the only instance that has come to our knowledge of the capture of an adult in this neighbourhood.

213. *Red-throated Diver* (*Colymbus septentrionalis*).— An adult Red-throated Diver, in nearly full summer plumage, was caught in a stake-net on the coast, on the 1st of May. Notwithstanding the period of the year, the bird was very much in moult.

214. *Foolish Guillemot* (*Uria Troile*).—No less than three specimens of this bird have been captured, at no great distance from Carlisle, during the present year. The first in the beginning of January, in the river Edin near Linstock; the second on Rockcliff Marsh, on the 8th of April; the third was caught alive on Brugh Marsh, on the 10th of August. This species is very seldom seen in the immediate vicinity of Carlisle.

216. *Little Auk* or *Common Rotche* (*Mergulus melanoleucos*).—A female of this species was found dead on the coast, a short distance from Allonby, on the 6th of December; another was shot on the river Eden near Amathwaite Castle, in the latter end of January 1794: the only two specimens of this bird which have been detected in this district that we are at present aware of†.

234. *Roseate Tern* (*Sterna Dougallii*).—A fine male of this beautiful Tern, beyond all doubt the most elegant of the Bri-

* Phil. Mag. and Annals, N.S., vol. viii. p. 448.

† Hutchinson's History of Cumberland, vol. i. p. 20.

tish Sternidæ, was accidentally shot near Brugh Marsh Point, on the 26th of July. For the last five years we have diligently searched after this bird in this quarter without success, and we have little or no doubt that the above was an accidental straggler on its passage to the south.

A few Meteorological Remarks on the Spring, Summer, and Autumn of 1834, *at Carlisle.*

The weather during the greater part of the month of March, especially from the 10th to the 27th, was remarkably fine and mild; on the 29th, however, there were several smart hail-showers, and on the 31st the western mountains were completely covered with snow. Nearly the whole of April was exceedingly chilly and cold; early on the morning of the 29th we had a slight fall of snow, which, however, almost immediately disappeared, and after the 30th it became fine and seasonable.

The summer and autumn, generally speaking, were fine, yet somewhat showery, particularly during the latter end of August and the greater part of September, which slightly injured the wheat and other crops in many parts of this district. From the end of September to the 10th of November, the weather here was almost unprecedentedly mild and dry.

Carlisle, Nov. 10, 1834.

LXVIII. *On certain Optical Effects of the Magnetic-Electrical Machine, and on an Apparatus for decomposing Water by its means. By Mr.* Edward M. Clarke.

To the Editors of the Philosophical Magazine and Journal.

Gentlemen,

TRYING the effect of the magnetic electrical machine on the optic nerves, I observed the following curious phænomenon. On grasping in one hand (which had been previously wetted with vinegar) one of the conductors, insulating the other hand with a glove, and slightly pressing the extremity of the other conductor to the wetted forehead, the mouth was affected with a metallic taste, similar to that produced when silver and zinc are brought into contact with the tongue, but much stronger. On closing my eyes I observed, where the conductor touched the forehead, a luminous disk, the light of which emanated in waves from a bright spot in the centre. The luminous disk was bounded by a strongly marked black circle, outside of which was more light, similar to that of the

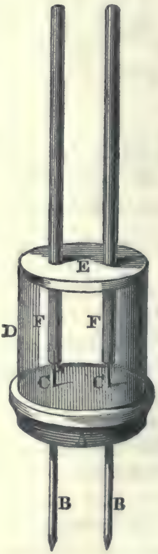
disk, but of less brilliancy. On communicating this to Dr. Faraday, he kindly suggested the trying the effect of a piece of wetted paper placed between the forehead and the conductor: the result was, the figure was better defined and more vivid. He further recommended the trial of a metallic disk, point, and line, successively, instead of the hollow cylindrical conductor as before; but no apparent change was visible in its effects. The arrangements of the terminating wires of the conductors is the same as already described in my former paper, p. 169. Care must be taken that the wires of the conductors are not removed from the mercury in which they are immersed, otherwise (as I have experienced) a violent *secondary* shock will be felt.

The apparatus heretofore used for the decomposition of water being defective, in so far that the connexions were imperfectly formed, did not thoroughly answer the purpose intended for the magnetic electrical machine. I send you a sketch of one constructed by myself, which answers *fully* the purposes for which it was intended, and has given satisfaction to all who have obtained them form me.

Explanation of the Figure.

A. A hard wood cup.
B B. Two copper wires, having two platinum wires,
C C, Soldered to their extremities.
D. A piece of glass tube cemented into A.
E. A cork fitting loosely into D.
F F. Two glass tubes closed at one end and fitted tightly into E.

Introduce B B into the connecting holes of the magnetic electrical machine, and move E F F from D; pour dilute sulphuric acid into D, so as to cover C C; fill the tubes F F also, and place them as before.



39, Charles street, Parliament street,
Feb. 14, 1835.

EDWARD M. CLARKE.

LXIX. *Trigonometrical Height of Ingleborough above the Level of the Sea.* Part II. *By* John Nixon, *Esq.*

[Continued from p. 261, and concluded.]

Of the Vertical Angles.

THE horizon sector was furnished with new arcs and verniers (the former in February 1827, and the latter in January 1832,) divided by the best engine in London, yet decidedly inferior in accuracy to the original graduations by Allan. Formerly the bubble of each cross level was adjusted to its mark when its arch stood parallel to a plumb line suspended near it, but latterly the adjustment has been effected in a superior manner. A block of wood $8\frac{1}{2}$ inches high, 6 long, and $2\frac{1}{2}$ thick, planed with its ends and sides perpendicular to its base, was mounted with a spirit-level, by which the base (by the process of reversing) could be set truly level. In this state, either arc when placed in exact contact with that end of the block in which recesses had been made for the protruding vernier, &c. would be vertical. Supposing the inclination of the arcs to be even 1°, an altitude of 2400 feet would be measured only 4 inches in excess, or in the proportion of the secant of the angle of inclination to radius.

In making bisections of pale, dim, or very distant objects, a dot* of about the same diameter as that of the vertical wire (spider's line), and adhering to one side of it a few minutes above the middle of its height, was successfully made use of up to 1832, when the filament mentioned in Lond. and Edinb. Phil. Mag., at page 166 of volume iv., was substituted. When the object was so near or dark that the dot or filament could not be seen distinctly against it, recourse was had to the horizontal wire, which was pointed in the first instance a little too high, and then gradually lowered (by moving a light weight placed within the stand of the sector in the direction of the object,) until the lower edge of the wire and the base of the signal, &c. seemed (from the inflection of light?) suddenly to commence running into each other. Zenith distances thus measured—as the second observation, with the telescope inverted, is made with the *opposite* edge of the wire and will be equally in defect with the preceding one—require in strictness a minute correc-

* The substitution of the dot for the horizontal wire arose from the impossibility of measuring the depression of the horizon of the sea with the latter. [It may be useful to some of our readers to refer in this place to the substitution of a dot for cross wires made by Mr. Gardner, in the trigonometrical operations for determining the difference of longitude between Paris and Greenwich, as stated by Capt. Kater in the Philosophical Transactions for 1828, p. 194—5, and considered by him to be a very important improvement in the theodolite.—Edit.]

tion *additive* for the semidiameter of the wire. As the arcs are not fixed exactly parallel to each other, the dot does not make precisely half a revolution downwards on inverting the telescope, and therefore cannot come to the previous perpendicular distance from the axis of the cylindrical telescope by a quantity (too trivial, however, to be regarded,) equal to this distance multiplied by the versed sine of the deviation of parallelism of the arcs. It may be remarked also that when the cross wires are properly adjusted, the perpendicular one, from a defect in the stop, cannot be set quite parallel to either arc. This was first noticed on observing the dip of the sea, the horizontal wire being slightly inclined to the edge of the sea when either arc was vertical; but the deviation is not of a nature to vitiate the measurements. The reversing point* of neither of the great levels, but particularly of that marked G, proved so constant as heretofore; the seasoning which the levels had gradually acquired from repeated shocks in travelling, and by exposure to extremes of temperature, having been disturbed by dismounting them on commencing the survey and by frequent alteration of the adjustments, never in the course of any campaign, but during the intervening winters. As the fluctuation must have taken place chiefly on transporting the sector from one station to another rather than at the time of observation, the angles cannot have been materially affected in consequence. A register of the reversing points for each level is subjoined in a note†. Generally the sector

* That degree of the scale at which the middle of the bubble stands when the axis of the cylindrical tube of the telescope lies parallel to the horizon.

† *Dates.*			*Level* G.	*Level* L.	*No. of Observations.*
			°	°	
1829.	August	20.	74·6	71·2	2
		21.	73·3	69·9	2
		22.	75·2	72·5	3
		25.	77·0	73·0	2
		28.	77·9	73·2	1
	September	3.	79·0	70·3	2
		14.	78·8	71·5	1
		15.	77·5	71·8	2
		16.	74·2	70·5	2
1830.	October	1.	78·1	70·2	2
		2.	79·7	72·8	3
		4.	79·3	71·7	2
		14.	79·1	70·7	4
		21.	77·7	71·3	2
	November	2.	80·0	72·0	2
1832.	July	25.	73·1	72·6	6
		27.	72·2	68·3	3
	September	15.	75·8	70·0	2
		18.	76·4	69·5	1

(1° of the scale is about 2″.)

The sector was supported either by solid masonry or bedded rock.

was supported by a firm pile of stones surmounted by a level flag, but in calm weather it was occasionally placed upon a large circular board, slightly concave at the upper surface, which was screwed firmly by its brass centre to the staff of the theodolite set up in the secure manner already decribed.

As the atmospherical refraction is generally fluctuating, the best method of obtaining its mean value correctly from the reciprocal observations and depressions, will be to class the observations at the several stations according to their dates rather than by the mean of the whole series. The following list, constructed on this plan from sixty-four observations made on eighteen different days in 1829, 1830 and 1832, exhibits a *mean* refraction of about $\frac{1}{17{\cdot}3}$ of the contained arc. From this ratio the deviation of any day's observations (which is given in the last column,) is generally not only inconsiderable, but occurs in small arcs, where its effect on the differences of level becomes unimportant. With regard to the few striking exceptions, the one at Farleton Knot, marked K, was derived from a hasty measurement, on one arc only, of the elevation of Ingleborough as it was rapidly becoming obscured by mist. Those at Hest Wall originate, no doubt, in that horary variation of the refraction occurring in low situations on calm bright days, which rendered so uncertain the measurement of the height of the tide. All the observations at Clougha, marked C, with the exception of the three first made—those of Ingleborough,—concur in giving a refraction in excess, which may, perhaps, be accounted for by the wind, which was scarcely sensible at first, soon after blowing a strong gale* from the north-west, the quarter fronting the steep and lofty acclivity on which the pikes stand, and occasioning a condensation of that portion of air through which the rays from the several signals would finally pass. All the angles, but in particular the concluding one, that of the Breakwater pole, were uncertain to a few seconds, from the tremulous motion of the pile supporting the sector, which had been constructed, very improperly, partly of sods. The letters in the list refer to the dates given in the register of the observations.

* The strong breeze off the bay of Morecambe, which had blown at Hest Bank all the morning, subsided about the time the gale sprung up at Clougha.

Observed Refractions.

Stations.		*Arc.*	*Refr.*	*Deviation from Mean.*
Between Farleton Knot (L) and	Hutton-Roof Moor (O)	1′ 40″	−2″·5	−8″
— Warton Crag (F) —	Hest Wall (U)	2 39	+11·7	+ 2·5
	do. (V)	2 39	15·3	+ 6
	do. (W)	2 39	15 3	+ 6
— Warton Crag (G) —	Hutton-Roof Moor (O)	4 16	16·0	+ 1·5
	do. (P)	4 16	14·8	0
— Farleton Knot (K) —	Warton Crag (F)	4 49	18·5	+ 2
— BreakwaterPole(R) —	Clougha Pike (A)	5 50	16·0	− 4
	do. (C)	5 50	32·8	+13
— BreakwaterPole(R) —	Hutton-Roof Moor (O)	7 26	27·5	+ 2
	do. (P)	7 26	31·0	+ 5·5
— Warton Crag (F) —	Clougha Pike (A)	7 42	18·7	− 8
	do. (C)	7 42	35·0	+ 8·5
— Farleton Knot (K) —	Hest Wall (U)	8 23	16·7	−12
	do. (V)	8 23	25·0	− 3·5
	do. (W)	8 23	26·3	− 2·5
— Clougha Pike (C) —	Hutton-Roof Moor (O)	9 42	38 3	+ 5
— Ingleborough (T) —	do. (P)	10 5	37·5	+ 3
	do. (Q)	10 5	41·0	+6·5
— Ingleborough (S) —	Farleton Knot (J)	11 8	39·5	+1·5
	do. (K)	11 8	30·3	−8
	do. (L)	11 8	37·5	−1
	do. (M)	11 8	36·5	−1·5
	do. (N)	11 8	36·5	−1·5
— Clougha Pike (C) —	do. (K)	11 9	35·4	−3·0
	do. (L)	11 9	37·2	−1·0
Ingleborough (S) and (T) ...... —	Clougha Pike (A)	13 22	44·5	−1·5
	do. (C)	13 22	+40·0	−1·6
	Sum	3° 44′ 37″	12′ 58″	

Mean refraction of the whole $\left(\frac{12' \, 58''}{3^\circ \, 44' \, 37''}\right) = \frac{1}{17 \cdot 3}$; say $\frac{1}{17 \cdot 5}$.

Trigonometrical Differences of Level.

Explanation.—The angles of elevation (*El.*) and depression (*Dp.*) are given corrected for the cylindrical error of the instrument (= 20″). At every station the height of the eye above the point there selected for bisection is stated, and from these data the differences of level are computed with a *constant* refraction of $\frac{1}{17 \cdot 5}$; but when any other point has been bisected, its height above (+) or below (−), the standard datum, is given within brackets. The distances prefixed to the angles are those from the sector to the point observed*. The devia-

* Call S the signal at the station, P the adjacent place of the sector, and O the distant signal observed; then add the log. cosine of the angle S P O

tion of the line of collimation from its mean value for each campaign is arranged in the last column; the bisections being marked D, F, or W, accordingly as they were made by the dot, filament, or wire.

At Clougha West Pike.

Dates. (A.) August 20, 1829, from 3 to 4 P.M. Sector on board. Eye 3½ feet above *the ground between the pikes.*—(B.) October 18, 1830, at 3 P.M. Eye 4½ feet.—(C.) September 18, 1832, from 1 to 3 P.M. Sector on a pile of stones and sods. Eye 3 feet.

Date Reference.	Station, &c. observed.	Distance.	Angle.		Diff. of Level.	Dev. Coll.	
		Ft.	° ′ ″		Ft.	″	
A	Ingleborough	81522	0 36 44	El.	+1015·0	2·5	W.
A	do.	...	0 36 42	..	+1014·2	3·0	
C	do.	81520	0 36 40	..	+1012·8	1	
C	do.	...	0 36 39	..	+1012·2	0·5	F.
C	do. [tower top + 22·3]	81343	0 37 32	..	+1009·0	3	
A	Hest Breakwater Pole, *top*	35590	2 10 18	Dp.	−1318·4	1	W.
C	do.	35587	2 9 36	..	−1312·5	9	
C	Black Comb	158943	0 2 2	El.	+ 630·3	2	
C	Farleton Knot	68036	0 29 28	Dp.	− 482·2	7·5	F.
C	Hutton Roof Moor	59132	0 31 8	Dp.	− 458·7	1	
C	Warton Crag	46933	1 3 29	Dp.	− 817·4	6	
A	do.	46937	1 4 4	..	− 825·0	5·5	
A	Lancaster Church tower, top	24558	2 40 19	Dp.	−1129·8	0	W.
A	do.	...	2 40 24	..	−1130·4	1	
B	do.	...	2 40 31	..	−1130·2	2·5	D.

At Aqueduct Bank.

Dates. (D.) August 21, 1829, from 4½ to 5½ P.M. Eye 6 feet above the Lancaster Canal when full (?).—(E.) August 25, 1829, from 10 A.M. to noon. Eye, 6 feet. Sector on board both days.

			Ft.	° ′ ″		Ft.	″	
D	Ingleborough	[+1 ft.]*	91528	1 19 55	El.	+2310·0	1	W.
E	do.		...	1 19 40	..	+2303·1	6·5	
E	do.		...	1 19 47	..	+2306·5	2	D.
E	do.		...	1 19 45	..	+2305·6	5	
E	do.		...	1 19 38	..	+2302·5	2	
D	Clougha Pike	[West Pike to +6·5]	24822	2 56 9	El.	+1285·6	1	W.
D	do.		...	2 56 14	..	+1286·1	4	
E	do.		...	2 56 18	..	+1286·7	4·5	D.
E	do.		...	2 56 14	..	+1286·2	1	

to the log. distance S P, and the sum *minus* radius will give a correction which, added to or subtracted from the distance S O accordingly as the angle S P O is obtuse or acute, will give that of P O.

* At Ingleborough the eye must be elevated 1 foot above the base of the signal to clear the view of the Aqueduct Bank.

[*Aqueduct Bank, continued.*]

		Ft.	°	′	″		Ft.	″	
D	LancasterChurch tower, top	7412	1	9	14	El.	+156·5	1	W.
D	do.	...	1	9	20	...	+156·7	1	
E	do.	...	1	9	17	...	+156·6	4·5	
D	do. [N.W. pinnacletop + 9·7]	...	1	13	43	...	+156·5	5·5	

At Aqueduct Bridge.

Date. (Y.) July 24, 1832, from noon to 1 P.M. Sector on south end of eastern battlement of bridge. Eye 13 feet above canal when full.

		Ft.	°	′	″		Ft.	″	
Y	Ingleborough [Tower top +22·3]	91365	1	20	16	El.	+2300·9	4	F.
Y	do.	...	1	20	18	...	+2301·5	1·5	
Y	LancasterChurch tower *top**	7416	1	6	5	El.	+ 156·8	1	W
Y	do.	...	1	6	3	...	+ 156·7	1·5	

At Hutton Roof Moor.

Dates. (O.) October 1, 1830, from $0\frac{1}{2}$ to $3\frac{1}{2}$ P.M.—(P.) October 2, 1830, from 10 A.M. to 3 P.M.—(Q.) September 13, 1832, from 3 to $3\frac{1}{2}$ P.M. Sector each day on a pile of stones. Eye 4 feet above base of signal.

		Ft.	°	′	″		Ft.	″	
O	Breakwater Pole, top	45299	1	8	33	Dp.	− 856·1	1·5	D.
O	do.	...	1	8	42	...	− 858·1	1·5	
P	do.	...	1	8	27	...	− 854·8	2·5	
P	do.	...	1	8	23	...	− 854·0	5·5	
P	do.	...	1	8	42	...	− 858·1	1·5	
P	Ingleborough	61513	1	17	46	El.	+1475·6	2·5	
Q	do.	61505	1	17	54	...	+1478·1	2·5	F.
Q	do.	...	1	17	50	...	+1477·2	1·0	
P	do. [Tower, top +22·3]	61311	1	19	17	...	+1475·2	14·5	D.
P	do.	...	1	19	18	...	+1475·5	5	
Q	do.	61304	1	19	18	...	+1475·9	5	F.
O	Warton Crag	26032	0	50	3	Dp.	− 360·6	3	D.
P	do.	...	0	50	5	...	− 361·0	2·5	
O	Farleton Knot	10155	0	10	30	Dp.	− 24·8	0·5	
O	LancasterChurch tower, top	57668	0	44	18	Dp.	− 668·8	3	
O	do.	...	0	44	26	...	− 671·1	2	
P	do.	...	0	44	23	...	− 670·2	8	
O	Clougha Pikes, ground betw.	59145	0	22	18	El.	+ 461·7	3	
P	Black Comb	140482	0	16	19	El.	+1088·8	3·5	

At Warton Crag.

Dates. (F.) August 21, 1829, from 11 A.M. to $1\frac{1}{2}$ P.M.

* According to Mr. Binns, the tower is 97 feet 6 inches high, and the (levelled) fall from its base to the canal when full, 59 feet 11 inches 6 tenths; together $157\frac{1}{2}$ feet, or 1 foot more than by the above measurements. Taking the mean, the church tower top will be 157 feet above the canal, and 187 feet 4 inches (= 157+30·4) above the top of the Breakwater Pole.

Sector on board. Eye 4 feet above the ground at the signal. —(G.) October 4, 1830, from 11½ A.M. to 1½ P.M. Sector on the rock. Eye 5 feet.—(H.) October 15, 1830, from 1½ to 2½ P.M. Eye 5 feet.—(I.) July 25, 1832, from 6½ to 7 P.M. Sector on board. Eye 3¾ feet.

		Ft.	°	′	″		Ft.	″	
F	Hest Breakwater Pole, top [−1·1]	20836	1	24	2	Dp.	− 495·1	4	W.
G	do.	20830	1	24	10	...	− 495·8	2	D.
G	do.	...	1	24	11	...	− 496·0	0·5	D.
H	do.	...	1	24	2	...	− 495·1	5·5	D.
I	do.	20834	1	23	47	...	− 494·7	5	F.
F	do. [−24·7]	20836	1	28	3	...	− 495·9	2·5	W.
G	Ingleborough [Tower top, +22·3]	81847	1	12	4	El.	+1840·3	5·5	D.
G	do.	...	1	11	58	...	+1837·9	4·5	D.
G	do.	...	1	11	51	...	+1835·2	4·5	D.
G	do.	...	1	11	51	...	+1835·2	4·5	D.
I	do.	81837	1	12	8	...	+1841·3	2	F.
I	do.	...	1	12	8	...	+1841·3	3·5	F.
H	do.	...	1	11	53	...	+1835·8	3	D.
F	do. [+1·0]	82046	1	11	0	...	+1839·5	1	W.
F	do.	...	1	10	58	...	+1839·1	1·5	W.
F	do.	...	1	10	59	....	+1839·1	3	W.
F	LancasterChurch tower, top	36097	0	32	14	Dp	− 306·9	1	W.
F	do.	...	0	32	13	...	− 306·9	3	W.
F	Hest Wall, top	22227	1	12	7	Dp.	− 451·9	3	W.
F	Clougha West Pike, top [+6·5]	46944	0	56	55	El.	+ 821·5	3	W.
F	Farleton Knot	29346	0	36	53	El.	+ 337·1	3·5	W.
G	Hutton Roof Moor ...	26032	0	45	8	El.	+ 361·1	7	D.
E	Horizon of the Sea to the S.S.W. at 12^h 35^m P.M.*	158520?	0	23	5	Dp.	− 528·2	1·5	W.

At Ingleborough.

Dates. (S.) September 2, 1829, from 11½ A.M. to 3 P.M. Remarkably clear. Sector on signal pile. Eye 4 feet above its base.—(T.) October 26, 1830, from 12^h 30^m to 2^h 30^m P.M. Very clear, but intensely cold, with flakes of snow. Sector as before. Eye 4½ feet.

* It has been demonstrated at page 270, vol. v. that the included arc will be equal to the observed dip *plus* twice the refraction; consequently when the latter is $\frac{1}{17\cdot5}$ the apparent dip will be to the arc as 15·5 to 17·5 The angle (23′ 5″) increased in this proportion becomes 26′ 4″, for which arc the refraction will be 1′ 29″·5, and the curvature $\left(\frac{26' \, 4''}{2} = \right)$ 13′ 2″. With the distance corresponding to the arc (158520 feet,) and the tangent of the dip, corrected for curvature and refraction (= 11′ 32½″) the height of the eye will be 532·2 feet and that of the Crag 528·2 feet.

		Ft.	°	′	″		Ft.	″	
T	Ingleborough tower, *top*	188	5	23	42	El	+ 22·3		
S	Farleton Knot	67990	1	21	0	Dp.	−1500·8	0	
S	do.	...	1	20	57	...	−1499·8	3·5	
T	Hutton Roof Moor	61513	1	27	2	...	−1473·2	0	
T	do.	...	1	27	8	...	−1475·0	6	
S	Clougha Pikes, ground betw.	81530	0	49	0	...	−1017·6	0	
S	do.	...	0	49	0	...	−1017·6	0 5	D.
T	do.	...	0	48	48	...	−1012·8	3·5	
T	do.	...	0	48	54	...	−1015·2	7·5	
S	Lancaster Church tower, top	97198	1	23	3	...	−2145·2	1·5	
S	Black Comb	201970	0	21	16*	...	− 383·8	0	
T	do.	...	0	21	6	...	− 374·1	1·5	
T	do.	...	0	21	10	...	− 378·0	3	

At Hest Breakwater Pole.

Date. (R.) October 21, 1830, from 10 to $10\frac{1}{2}$ A.M. Sector on board. Eye ($3\frac{1}{2}$ feet above base,) $24\frac{1}{2}$ feet below top of pole, which is 28 feet high.

			°	′	″		Ft.		
R	Clougha West Pike, top [+5·0]	35594	2	7	26	El.	+1317·2	6·5	
R	do. do. ...	...	2	7	24	...	+1316·9	0·5	D.
R	Hutton Roof Moor ...	45299	1	3	41	...	+ 858·1	0·5	

At Farleton Knot.

Dates. (J.) Aug. 28, 1829, at 2 P.M. Sector on a rock. Eye 1 foot above base of signal; (a tremendous gale from the north.)—(K.) Aug. 29, 1829, from 10 A.M. to $2\frac{1}{2}$ P.M. Sector on a pile of stones. Eye 1 foot.—(L.) Sept. 30, 1830, from 3 to 5 P.M. Sector as last.—(M.) Oct. 12, 1830, from 11 A.M. to 1 P.M. Sector as last.—(N.) Sept. 15, 1832, from $3\frac{1}{2}$ to $4\frac{1}{2}$ P.M. Sector on board. Eye 1 foot†.

		Ft.	°	′	″			″	
M	Hest Breakwater Pole, top	49983	1	1	2	Dp.	− 833·6	3·5	D.
N	do.	49994	1	0	58	„	− 832·8	4·5	F.
J	Ingleborough, ...	67990	1	10	55	El.	+1501·0	1	W.
K	do.	67985	1	10	36	..	+1495·0		
L	do.	67987	1	10	50	..	+1499·6	1·5	D.
N	do.	67986	1	10	50	..	+1499·6	5	
N	do.	......	1	10	45	..	+1498·0	4	F.
N	do.	......	1	10	44	..	+1497·7	3·5	
L	do. [Tower, top +22·3]	67793	1	12	9	..	+1498·6	5·5	
L	do. [Tower, top +22·3]		1	12	15	..	+1500·6	4·5	
M	do. [Tower, top +22·3]		1	12	13	..	+1500·0	2·5	D.
M	do. [Tower, top +22·3]		1	12	12	..	+1500·0	2·5	
M	do. [Tower, top +22·3]		1	12	8	..	+1498·4	3	
N	do. [Tower, top +22·3]	67792	1	12	17	..	+1501·4	3·5	F.

* By Mudge, 22′ 24″; (height of Eye $5\frac{1}{2}$ feet.)

† The beds dip 30° to 40° from the edge of the cliff on which the signal stands.

			Ft.	° ′ ″		Ft.	″	
K	Lancaster Church tower, top		63992	0 39 25	Dp.	− 646·2	2	D.
	do.		......	0 39 26	..	− 646·6	4·5	
L	do.		63991	0 39 26	..	− 646·6	8	
K	Warton Crag .. .		29344	0 41 40	Dp.	− 336·3	1·5	
L	Hutton-Roof Moor ..		10145	0 7 4	El.	+ 24·0	2·5	
K	Hest Wall, top		51140	0 57 1	Dp.	− 791·7	2	
K	Clougha West Pike, top	[+6·5]	68037	0 19 40	El.	+ 481·6	1	
	do.			0 19 34	..	+ 479·5	3	
L	do.	[+5·0]	......	0 19 36	..	+ 481·5	2·5	
M	Black Comb		134460	0 18 30	El.	+1106·5	6·5	
	do.		......	0 18 28	..	+1105·3	1·5	

At Hest Wall.

Dates. (U.) Aug. 24, 1829, at 3 P.M.—(V.) Sept. 14, 1829, at 12½ P.M.—(W.) Sept. 16, 1829, at 3 P.M.—(X.) Oct. 20, 1830, at 11 A.M. Eye 0½ foot above Wall top.

			Ft.	° ′ ″		Ft.	″	
U	Warton Crag		22222	1 8 10	El.	+451·7	1	W.
V	do.		......	1 8 17	..	+452·5	6·5	D.
W	do.		......	1 8 17	..	+452·5	0·5	
X	Hutton-Roof Moor ..		46052	0 56 27	El.	+814·8	0	
	do.		......	0 56 27	..	+814·8	0·5	
U	Farleton Knot		51149	0 49 5	El.	+786·0	1·5	W.
V	do.		......	0 49 22	..	+790·4	1	D.
W	do.		......	0 49 24	..	+790·9	1·5	
Aug. 24, 1829.	Breakwater Pole,	top	2339·3	1 4 58	Dp.	− 43 2		
25, 1829.	do.	do.	......	1 4 58	..			
July 25, 1832.	do.	do.	......	1 5 4	..			
Aug. 24, 1829.	do.	base	......	1 45 46	Dp.	− 71·2		
.. ..	do.	do.	......	1 46 13	..			
Aug. 25, 1829.	do.	do.	......	1 46 0	..			
.. ..	do.	do.	......	1 46 28	..			
Oct. 14, 1830.	do.	do.	......	1 46 23	..			
.. ..	do.	do.	......	1 45 46	..			
Oct. 20, 1830.	do.	do.	......	1 46 28	..			
.. ..	do.	do.	......	1 46 6	..			

In 1829 Hest Bridge top measured 17 feet above the Lancaster Canal, and 4·2 feet above Hest Wall; whence the Wall is 12·8 above the canal. The Pole top being 43·2 below Hest Wall will be 30·4 lower than the canal.

The following table exhibits for every intermediate station each day's observed difference of level between Ingleborough and the Breakwater Pole top, derived as well directly as through the medium of Lancaster church tower and Hest Wall, together with their respective heights above the Pole. When an observation of the hill was not accompanied on the

same day by one either of the pole or church, the deficiency was supplied from the mean of all those registered.

			By B. Pole	By L. Church.	By Hest Wall.	Means.
At Clougha Pike	2 Obs. ...	A	2330·0	2332·1		
	3 —	C	2323·6	2328·7		
At Aqueduct Bank	1 —	D	2340·6	2341·0		
	4 —	E	2335·0	2335·4		
At Aqueduct Bridge	2 —	Y	2331·8	2332·0		
At Warton Crag	3 —	F	2334·7	2333·5	2334·3	
	4 —	G	2333·0	2331·4	2332·8	
	1 —	H	2330·9	2330·1	2330·9	
	2 —	I	2336·0	2335·6	2336·4	
At Hutton-Roof Moor	3 —	P	2331·0	2333·0		
	3 —	Q	2333·5	2334·5		
At Farleton Knot	1 —	J	2334·3	2335·0	2335·9	
	0½ —	K	2328·2	2328·9	2329·9	
	3 —	L	2332·8	2333·6	2334·6	
	3 —	M	2333·0	2333·4	2334·4	
	4 —	N	2332·0	2333·1	2334·1	
Mean of each day's obs.			2332·9	2333·4	2333·9	2333·5
Do. of all the obs.			2332·4	2333·2	2334·1	2333·0

The altitude may be found exclusively from the depressions, at Ingleborough, of Farleton Knot, Hutton-Roof Moor, Clougha Pike, and Lancaster church tower, together with the elevations of the three stations above the pole, as measured at the Breakwater and Hest Wall, and that of the church tower as determined by levelling, &c.

By obs. of Farleton Knot	2332·5	Mean, 2332·5 feet.
Hutton-Roof Moor	2332·1	
Clougha Pike	2332·8	
Lancaster Church .	2332·6	

Giving the due weight to the different methods, the height of Ingleborough above the top of Hest Breakwater Pole may be considered as 2333 feet.

Height of Hest Breakwater Pole above the Tides.

Having filled up by interpolation the eight blanks in the given list of the observed heights of the Pole top above high water, from July 7 to August 7, 1832, the mean will be 26 ft. 8 in. By Holden's Tables, which are founded on five years' observations at Liverpool, and are considered very exact, the predicted mean height of the (day) tides within the same period is 14 ft. 10 in. above the old dock sill, which is 8 ft. 9 in. above the average low-water mark of spring tides, and 1 ft. 9 in. above that of neaps. To render Holden's heights

comparable with those of our list they must be subtracted from 41 ft. 6 in. (= 14 ft. 10 in. + 26 ft. 8 in.), when each day's difference will stand as follows:

1832.

July 7th .. + 5 inches.	July 18th .. − 2 inches.	(July 29th .. + 3 inches)
(8 .. +10	19 .. − 7	30 .. − 8
9 .. +10	(20 ☾ − 9)	31 .. −11
10 .. + 7	21 .. −12	Aug. 1 .. −14
11 .. +12	(22 .. − 2)	2 .. −12
12 ○ + 5	23 .. + 1	(3 ☽ − 9)
13 .. + 6	24 . − 1	4 .. − 8
14 .. + 1	25 .. + 3	(5 .. 0)
15 .. + 3)	26 .. + 3	6 .. + 2
16 .. + 7	27 ● + 1	7 .. − 5
17 .. + 2	(28 .. − 2)	

At *high water* the difference of level between spring and neap tides may be considered the same at both places.

Call PO the *observed* height of the pole top above the sea in a given state of the tide, and PH its corresponding mean value for 1832--3, derived from Holden's Tables. 1. At *spring tides** PH will be 23 ft. at mean high water, and 50·3 at mean low water. July 28th, 1832, PO was 22·6, and the height of the tide (at Heysham) 29·3; whence PO would become 51·3 at mean low water, spring tides. 2. At *neap tides** PH is 29·6 at mean high water, and 43·3 at mean low water. July 20th, 1832, PO was 28·10, and the height of the tide at Heysham 18·3; whence PO may be stated at 46·5 at mean low water neap tides. 3. At mean high water PH will be $\left(\frac{23 + 29{\cdot}6}{2}\right) = 26{\cdot}3$, or 26·2 by the mean of every day tide within the two years. 4. At mean low water PH is $\left(\frac{50{\cdot}3+43{\cdot}6}{2}=\right)46{\cdot}10$, and $\mathrm{PO}=48{\cdot}10\ \left(=\frac{51{\cdot}3+46{\cdot}5}{2}\right)$.
5. At the mean level of the sea PH will be 36·6; the measurements at Heysham give PO = 38 at neaps and 37 at springs, mean 37·6 †.

January 29th, 1823. Mr. Binns levelled from the canal at Hest to the shore 400 yards to the northward, and thence 1923 yards on the sands to the lowest (?) part of the channel of the Keer ‡, and found the fall 76·9 (or 46·5 below the pole).

* Spring tides were considered the two highest, and neap tides the two lowest tides within a lunation.

† At Liverpool the difference of level between springs and neaps is much the same at high and low water, or about 7 ft.; but at Heysham the difference at low water cannot exceed 5 ft. It may therefore be doubted whether the lake subsides at spring tides to the level of the open sea.

‡ "A small channel near the land at Hest was lower by 3 inches than the point levelled to."

As the tide measured 25·9 in height, it would have been at high water 20·8 below the pole top, or about the level of the highest tide in my list; at least a 30-ft. tide. It may therefore be concluded, as indeed Mr. Binns intimates, that the point levelled to was some feet above low water. In proof, he states that the canal, when full, is 76½ ft. above the sill of Glasson dock gates, (consequently about the level of the channel of the Keer,) from which the tide sometimes ebbs out three to five feet.

The height of Ingleborough may now be stated as 2370·5 ft. above the mean level of the Irish Sea, and as

2384·5 ft. above *mean* low water spring tides *;
2379·5 — — — neap —
2356·0 — *mean* high water spring tides;
2362·5 — — — neap —.

The height of each sector station above mean low water spring tides, obtained on the same plan as that of Ingleborough, is given in the following list.

	Clougha.	Warton Crag.	Farleton Knot.	Hutton-Roof Moor.
By obs. at Breakwater	1368·3			909·4
Hest Wall	......	546·7	883 6	909·3
Warton Crag	1367·5	546·1	883·1	907·1
Farleton Knot ..	1365·8	548·5	884·9	908·9
Hutton-Roof Moor .	1369·8	547·3	883·3	908·1
Clougha Pike	1369·3†	544·3	884·0	907·5
Ingleborough	1368·1		883·7	909·8
Aqueduct Bank ..	1368·1			
Mean	1368·1	546·6	883·9	908·6‡

Having measured from three intermediate stations in Wharfdale, the difference of level between Ingleborough and Roseberry Topping, the resulting altitude of the latter exceeded considerably its elevation above the German Ocean at Redcar, as measured by Col. Mudge from the intermediate station at Burleigh Moor. It is however evident that either the data for determining its distance from Burleigh Moor are incorrectly stated, or that an error of −1802 feet (= −33 ft. in the altitude,) has been committed in the calculation.

The height of Black Comb measures 1989·8 from Farleton Knot, 1997·4 from Hutton-Roof Moor, 1998·4 from Clougha, and 2005·7 from Ingleborough; mean 1997·8. Col. Mudge states it at 1919 feet.

Chapel Allerton, near Leeds,
Feb. 5th, 1833.

JOHN NIXON.

* Hitherto called 2374·5 ft. Mudge makes it 2361 ft.

† Rejecting the obs. marked (C).

‡ Summit of moor, 911·6 ft.

LXX. *On a Decimal System of Monetary Calculation, founded on the present Denominations of Money and Coins in Great Britain.* By Mr. SAMUEL READ, *Member of the School of Naval Architecture.*

To the Editors of the Philosophical Magazine and Journal.

GENTLEMEN,

WHILST everybody admits the superiority in every respect of a decimal system of calculation in regard to weights and measures and money, and at the same time can only regret that the habits we have imbibed prevent the execution of such a desirable measure as the introduction of a decimal graduation of our monetary scale, I have not seen or heard of any attempt to develop such a system from the *present* money table, which, remarkable as it may appear, contains a decimal graduation perfectly available in all money calculations, and with a very slight expense might be ingrafted on our present coinage.

Assuming the *shilling* as the *unit*, and having *one copper* coin of a new value, the whole of our present coinage may be adapted to the decimal scale, which I shall presently deduce from the money table now in use. We shall not have to forget any of the present denominations of money, or to interfere with deeply rooted habits and prejudices, or to put the country to any other but a very trivial expense in effecting the alteration.

Taking, therefore, the shilling as the *unit*, I conceive it to be divided into ten parts, each of which cannot perhaps have a more significant name than a "tenth"; a "tenth" I suppose also to be divided into ten parts, each of which, from being the $\frac{1}{100}$dth of a shilling, may very properly be called a "cent"; hence the decimal graduation we have just now indicated only wants a step above the shilling to complete it, and that we most fortunately have ready to our hands in the "*half-pound*." The money table for *calculation* may therefore be thus simply constructed:

10 cents equal ...... 1 tenth,
10 tenths .... 1 shilling,
10 shillings .... 1 half-pound.

From a consideration of the above table it therefore appears that the only *new* piece of money *absolutely* necessary to connect the *present* coinage with this *decimal* scale is the *copper* "tenth," for this copper "tenth" would have a value of 1·2 penny; hence the *present farthing* would only be $\frac{1}{100}$dth of a

penny in *excess* of two "cents"; the *cent* being of course an imaginary denomination, and only necessary for the purpose of calculating by an uniform scale. In the same way the *present halfpenny* would be only $\frac{2}{100}$ or $\frac{1}{50}$ of a penny in *excess* of *four* cents; and lastly, the *present penny*-piece would be $\frac{1}{25}$ of a penny in *excess* of eight cents. We see, therefore, that the wear of the present copper coinage would soon cause, if it have not already caused, an equality, or a very near approximation to equality, between the present penny and 8 cents, between the present halfpenny and 4 cents, and between the present farthing and 2 cents. The comparison may, however, be better exhibited at one view as in the following table:

Proposed Scale.			Present Scale.				Present Coin.
2 cents	equal	to	·24	of a penny,	or	very nearly	*one* farthing,
4	—	—	·48	—	or	—	*one* halfpenny,
6	—	—	·72	—	—	—	*three* farthings,
8	—	—	·96	—	—	nearly	*one* penny;

and 10 cents would be represented by the proposed copper coin the "tenth."

In proceeding up the scale of our present *silver* coinage we have the following comparison:

5 tenths equal	...	1 sixpence,
10 —	...	1 shilling,
25 —	...	1 half-crown,
50 —	...	1 crown.

A tolerably simple progression of value, in as much as the third value, or half-crown, is five times the five-tenth piece, or sixpence, and the fourth value is also five times the shilling. It appears, therefore, that *all* the silver coins at present in use, with the exception of the half-crown, will be integral values of all the denominations of money our decimal scale has indicated.

If, however, the gradual introduction of two *new* silver pieces were allowed instead of the crown and half-crown, a much more simple progression might be adopted, having a series of values derived from the five-tenth piece, or sixpence, in the manner of a geometrical progression, whose common ratio is 2. Such an improved scale would stand thus:

5 tenths equal	....	1 sixpence,
10 —	...	1 shilling,
20 —	...	1 half-noble,
40 —	...	1 noble.

The revival in this table of a famous old English coin would put a much more convenient description of silver money into

circulation than the present crown and half-crown pieces, the former of which, in particular, from its large size, is ill adapted for carrying in the pocket.

As the highest denomination of money in the decimal scale proposed is the "half-pound," all *gold* coins ought to have some *multiple* value of the same. We have already the *half-sovereign* of ten shillings and the *sovereign* of twenty shillings, to which might be added a *double*-sovereign. In this way the *consecutive* values of the gold coins would also form a geometrical progression, having 2 for a common ratio, as in our proposed table for silver coins *.

Many complaints have been made of the want of a silver coin of a lower denomination than the sixpence, purchasers having frequently the inconvenience of carrying five pennyworth of copper about them. There is no doubt that it would be a great convenience to the public to have a 25-cent piece in silver, which would be, in fact, a silver threepenny piece.

It now only remains to give an example or two of the simplicity and readiness of arriving at results by the adoption of the proposed decimal scale. Suppose that we have 35 tons, at $9l.\ 11s.\ 6\frac{1}{4}d.$ per ton:—to find the amount.

$$9l.\ 11s.\ 6\tfrac{1}{4}d. = 19{\cdot}152 \text{ half-pounds.}$$

$$\begin{array}{r} 35 \\ \hline 95760 \\ 57456 \\ \hline 2)\ 670{\cdot}320 \\ \hline 335l.\ 3s.\ 2t. \end{array}$$

Suppose we have $76\frac{1}{2}$ cwt., at $3l.\ 13s.\ 5\frac{1}{4}d.$ per cwt.

$$3l.\ 13s.\ 5\tfrac{1}{4}d. = 7{\cdot}343 \text{ half-pounds.}$$

$$\begin{array}{r} 76\tfrac{1}{2} \\ \hline 44058 \\ 51401 \\ \hline 558{\cdot}068 \\ 3{\cdot}671 \\ \hline 2)\ 561{\cdot}739 \\ \hline 280l.\ 17s.\ 3t.\ 9c., \text{ or } 280l.\ 17s.\ 4\tfrac{3}{4}d. \end{array}$$

* The ten-shilling gold piece, or half-sovereign, might, with considerable propriety and significance, be termed "regent," and substituted in our de-

The following table would at first give additional facility in changing the decimal scale into the present, and *vice versâ.*

d.		Decimal Values of the Half-Pound.	*d.*		Decimal Values of the Half-Pound.
$\frac{1}{4}$	=	·0020	$3\frac{1}{4}$	=	·0271
$\frac{1}{2}$	=	·0041	$3\frac{1}{2}$	=	·0291
$\frac{3}{4}$	=	·0062	$3\frac{3}{4}$	=	·0312
1	=	·0083	4	=	·0333
$1\frac{1}{4}$	=	·0104	$4\frac{1}{4}$	=	·0354
$1\frac{1}{2}$	=	·0125	$4\frac{1}{2}$	=	·0375
$1\frac{3}{4}$	=	·0145	$4\frac{3}{4}$	=	·0395
2	=	·0166	5	=	·0416
$2\frac{1}{4}$	=	·0187	$5\frac{1}{4}$	=	·0437
$2\frac{1}{2}$	=	·0208	$5\frac{1}{2}$	=	·0458
$2\frac{3}{4}$	=	·0229	$5\frac{3}{4}$	=	·0479
3	=	·0250	6	=	·0500

Being desirous of giving publicity to the results of my inquiries on this subject, I have put them into the present form, in the hope that you will be able to find for them a spare page or two of your valuable scientific periodical.

I beg to remain, Gentlemen,

Your obedient Servant,

His Majesty's Dockyard,
Chatham, Feb. 4th, 1835.

SAMUEL READ.

LXXI. *On the Immersion of Copper for Bolts and Ship-sheathing in Muriatic Acid, as a Test of its Durability.* By DAVID MUSHET, *Esq.*

THE durability of copper for bolts and ship-sheathing being an object of great national importance, and as there is no better test of its resistance to waste than immersion in muriatic acid, the following experiments, made thirteen years ago, will, it is hoped, be found not uninteresting.

Small quantities, presenting nearly equal surfaces of each of the kinds of copper described in my last communication, p. 324, namely, pure shotted copper of the quality from which brass is made, and shots obtained from unrefined copper, were separately immersed in equal weights of muriatic acid. The immersion having been continued for forty-eight hours, the acid was poured off, and the copper washed repeatedly and

cimal money table for the term "half-pound;" our accounts being kept in regents, shillings, tenths, and cents, instead of half-pounds, shillings, tenths, and cents. For this suggestion I am indebted to a friend well known in scientific circles, and to whom I have communicated the subject-matter of this paper.—*March* 11*th*, 1835. S. R.

thoroughly dried. The pure copper had lost at the rate of $5\frac{1}{2}$ grains in 100. But the unrefined copper, on being weighed, seemed to have gained half a grain; so that either a mistake must have been made in the weighing, or else a portion of unexpelled moisture had remained in the porous flakes of the copper.

Six ounces of unrefined copper were mixed with three times their bulk of charcoal, and exposed for six hours to a high heat of cementation, much beyond what in the absence of the cementation would have sufficed to melt the copper. The flakes of copper were found surrounded by the charcoal, welded together without fusion, and soft and extremely flexible. Six ounces of the pure copper shots were treated in a similar manner; but the result was so far different that no adhesion of the masses had taken place, and the only perceptible change was a slight cracking or bursting upon the surface of the spheroids, which may be considered as a prelude to fusion. Both results were melted down with charcoal and run into iron moulds. The unrefined copper, when cold, was the strongest and softest; a bar of it, about $\frac{3}{8}$ths of an inch thick, cut easily across with a knife, and in colour and general appearance it very nearly resembled Swedish copper. Another piece was flattened out thin when cold for the purpose of immersion in the muriatic acid. The pure copper was melted in rather a higher degree of heat, and although not teemed until it had assumed a creamy surface, and the crucible had fallen to a low red temperature, it was crystallized throughout the whole fracture. The surface and the fracture of this copper were of a red colour; the *body* weak, and tearing with facility into pieces. Fragments for immersion were cut off and flattened.

The following specimens were then placed separately in muriatic acid.

No. 1.	Pure copper, cut off with a chisel,	... 53	grains.
2.	Ditto, flattened,	... 30	—
3.	Unrefined copper, cut off with a knife,	$39\frac{1}{2}$	—
4.	Ditto, flattened, in which stuck a minute portion of the knife	42	—

On the morning of the third day the following remarks were made upon their respective solutions.

No. 1, Light green colour, very transparent when dashed against the sides of the glass. No. 2, Equally transparent, but the green was brownish and not so decidedly cupreous. After continuing the immersion for 48 hours longer, the acid was poured off and the specimens were well washed and dried.

No. 1, That weighed 53 grains, now weighed ... $39\frac{1}{2}$ grains.
Loss $13\frac{1}{2}$ grains. Equal to 25·4 per cent.
No. 2, That weighed 30 grains, now weighed ... $11\frac{1}{2}$ —
Loss $18\frac{1}{2}$ grains. Equal to 61·6 per cent.
No. 3. Unrefined copper flattened, $39\frac{1}{2}$ grs., now weighed ... 19 —
Loss $20\frac{1}{2}$ grains. Equal to 50 per cent.
No. 4. Unrefined copper bar, 42 grs., now weighed $38\frac{1}{2}$ —
Loss $3\frac{1}{2}$ grains. Equal to $8\frac{33}{100}$ per cent.

It would appear from this experiment that the unrefined copper resists waste in the muriatic acid, in the same way, and to nearly the same extent, as in the cementation with lime mentioned in my last previous paper, p. 325.

In corroboration of this fact, we may take the following abstract of another series of experiments, wherein the specimens were weighed three times, at intervals of 48 hours between each weighing.

Unrefined copper,	1st immersion, lost	...	15	per cent.
Ditto,	2nd do.	...	$8\frac{3}{10}$	—
Ditto,	3rd do.	...	6	—
			$29\frac{3}{10}$	—
Pure copper,	1st immersion	...	25·4	—
Ditto,	2nd do.	...	9·7	—
Ditto,	3rd do.	...	11·1	—
			46·2	—

In favour of the unrefined copper, principally containing tin,—16 9 per cent. Two pieces of copper, the one pure the other unrefined, were immersed, under similar circumstances, for seven days. The unrefined copper lost 17 per cent. and the pure copper 45 per cent. To ascertain whether the greater indestructibility was owing to the tin which remained in the unrefined copper, I formed a bar of alloy as follows:

Pure copper	...	2880 grains.
Block tin	...	84 —

A proportion of tin about equal to 3 per cent. A piece from this bar, weighing about 183 grains, was exposed for seven days in muriatic acid, at the end of which time it was found to have lost 30 grains, or $16\frac{4}{10}$ per cent. The unrefined copper above mentioned lost, in the same time and under similar circumstances, 17 per cent., which is a striking correspondence. The same piece of tin alloy, at the end of five weeks, was found to have lost in all 76 grains, or $38\frac{1}{2}$ per cent. Pure

copper by the foregoing results lost in seven days' immersion 46·2 and 45 per cent.

In the first instance I was inclined to attribute the indestructibility of the unrefined copper in the acid partly to the effects of the charcoal in the cementation, seeing that the effect produced by that operation was much greater upon unrefined than upon pure copper. Whatever advantages may belong to the proper use of charcoal in the reduction and cementation of copper, (and I consider them not unimportant,) the addition of a small portion of tin will be sufficient to account for the superior resistance to waste which this alloy presents in the muriatic acid, over that of the common refined copper of this country. This incapacity to rapid oxidation which is presented by the alloy of tin with copper, suggests many useful hints to the artist and the manufacturer, of which advantage has already been taken in forming ship-sheathing and other articles.

David Mushet.

LXXII. *Insectorum nonnullorum exoticorum* (*ex Ordine* Dipterorum) *Descriptiones. Auctore* J. O. Westwood, *F.L.S. &c.*

[Continued from p. 281.]

PHILOPOTA, Wied. *Maculicollis*, Westw. Nigra; thorace anticè maculis 2 minutissimis, alterisque 2 parvis ad basin alarum fulvis; abdominis marginibus tenuitèr flavo notatis, segmentis terminalibus, sericie subaureâ tectis; antennis nigris; facie albidâ; femoribus nigris, apice rufis, pedum geniculis pallidis; alis infumatis.—Long. corp. lin. 4½. Exp. alar. lin. 11½.

Habitat in Brasiliâ. "Capta D. Swainson." In mus. nostr.

Lepidophora, Westw. (Fam. *Bombyliidæ.*)

Antennæ capite triplò longiores, squamulis obtectæ, articulo 1mo? brevi, 2ndo longo gracili, 3tio breviori latiori, stylo apicali. Proboscis antennarum dimidiò brevior. Thorax valdè gibbosus. Abdomen elongatum, parallelum, caudâ squamulosâ ornatum. Alæ farinosæ, nervis ut in *Cylleniâ* dispositis. Pedes longi, graciles.

Obs. Cel. Kirby et Spence hoc genus commemorant libro "Introd. to Ent." vol. iii. p. 646, pl. 12, f. 23, ubi Culicem cum Anthrace, &c., conjungere credunt.

Sp. 1. *Lep. ægeriiformis*, Westw. MSS. *Ploas ægeriiformis*, G. R. Gray, in Griff. An. K. pl. 128.

Niger; thoracis lateribus flavo pubescentibus; abdomine maculis 6 lateralibus flavis; alis infuscatis.—Long. corp. lin. 5½—6½. Exp. alar. lin. 11—14.

Habitat in Georgiâ Americæ.—In Muss. Brit. et nostr.

Obs. Toxophora lepidocera Wied. congenerica videtur.

Nemestrina, Latr. *Rhynchocephalus*, Fisch. *Fallenia*, Meig. t. 2.

Subg. 1. *Fallenia*, Macq. Palpi elongati, attenuati; antennarum stylo

cylindrico; alarum cellulâ 3tiâ submarginali minutâ, clausâ.—*Cytherea fasciata*, Fab.

Subg. 2. *Nemestrina* propriè sic dicta. Palpi minuti; articulis rotundatis; antennarum stylo setiformi 3-articulato; alarum regione apicali valdè transversè reticulatâ; oculis lævibus.—*N. reticulata*, Latr.; *longirostris*, Wied.

Subg. 3. *Trichophthalma*, West. Palpi magnitudine intermedii; articulis plùs minùsve ovalibus; antennis ut in subg. 2; alarum regione apicali longitudinalitèr nervosâ, nervis ut in *Fall. caucasicâ* (Meig. vol. 2. t. 16, f. 14.) dispositis, nervo ferè recto, e medio nervi subcostalis, apicem versus marginis postici obliquè currenti; nervo 2ndo apicali furcato; oculis pubescentibus.

Hìc pertinere videntur *Rhync. Tauscheri* Fisch., Meig. v. 6. pl. 66. f. 67. et *Rhyn. caucasica* Fisch., Meig. loc. cit.; etiam

Trich. bivittata, Westw. Thorace cinereo; capite magno; oculis fulvescenti-pubescentibus; proboscide capite longiori; abdomine nigro, vittis duabus longitudinalibus latis albis; antennis pedibusque rufescentibus; alis hyalinis; nervis costalibus et basalibus fusco-rufis, reliquis nigris.—Long. corp. (prob osc. excl.) lin. 7. Exp. alar. lin. 16.

Habitat in Novâ Hollandiâ.—In mus. nostr.— Communicavit Dom. Shuckard.

Trich. costalis, Westw. Thorace fusco; capitis facie albâ; oculis piceo-pubescentibus; abdomine rufescenti-fusco; basin et apicem versus corporeque toto subtùs pubescentiâ albo-cinerascenti indutis; pedibus rufescentibus; antennarum articulis terminalibus nigris; alis elongatis; costâ latè fuscanti; proboscide nigro; capite paullò longiori.—Long. corp. (prob osc. excl.) lin. 7. Exp. alar. lin. 17.

Habitat in Novâ Hollandiâ.—In mus. nostr.—Communicavit Dom. Shuckard.

Trich. obscura, Westw. Obscurè cinerea; pedibus rufescentibus; facie albâ; proboscide capite ferè duplò longiori; alis ad costam tenuitèr fuscantibus; ocello antico aliis remoto.—Long. corp. (prob osc. excl.) lin. 5½. Exp. alar. lin. 14.

Habitat in Africâ?—In mus. D. Hope.

Trich. subaurata, Westw. Fusca; pubescentiâ subauratâ tectâ; thorace lateribus et in medio longitudinalitèr pallidiùs bivittato; abdomine magìs fulvescenti, vittâ obscuriori centrali longitudinali; pedibus et antennis rufescentibus, harum setâ nigrâ, alis brevioribus; costâ latè fuscanti; proboscide capite plùs quàm duplò longiore.—Long. corp. (prob osc. excl.) lin. 5¼. Exp. alar. lin. 13½.

Habitat in Americâ meridionali (Valparaiso). In mus. D. Hope.

Obs. Sectio 3tia suprà descripta affinitatem generis *Nemestrinæ* cum *Hermoneurâ* facilè demonstrat, inde in ordine naturali genus *Nemestrina* locum intermedium tenet inter *Cyrtum, Lasiam*, &c. familiæ *Vesiculosarum* et *Hermoneuram* familiæ *Anthracidarum*.

Obs. Genus *Midas*, neuratione alarum similitèr insolitâ, gaudens ramulo laterali systematis, generibus suprà prædictis conjungi videtur. An genus osculans ad *Asilidas*, &c. adducens?

Apiocera, Westw. Genus quoad habitum *Midasibus, Corsomyzis* et *Nemestrinis* approximare videtur. Caput transversum. Antennæ capite breviores; articulo 1mo crasso, 2ndo parvo, his articulis cum setis rigidis armatis; 3tio parvo pyriformi; setâ minutâ terminali. Proboscis exserta, capitis longitudine. Palpi exserti, spatuliformes. Abdomen thorace ferè

duplò longius, obconicum. Femora postica haud incrassata. Tarsi bipulvillati. Alarum nervi ferè ut in *Midase* dispositi; nervo 3tio longitudinali, ante apicem furcato, recto; nervo 4to longitudinali supplementali, apice cellulæ 1mæ discoidali exeunti, inde cellulæ 4 posteriores marginales efformantur.

Sp. 1. *Ap. asilica,* Westw. Nigra; vertice, thoracis lateribus piceis; palpis albidis; alarum nervis nigris.—Long. corp. lin. 9½. Expans. alar. lin. 17.

Habitat in Novâ Hollandiâ.—In mus. nostr.

Sp. 2. *Ap. fuscicollis,* Westw. Obscurè fusca; thorace cinereo subvittato; palpis albidis; alarum nervis internis pallidis; corpore subtùs albido villoso. An varietas præcedentis?—Exp. alar. lin. 17.

Habitat in Novâ Hollandiâ?—In mus. D. Hope.

Pangonia, Latr., *Macroglossa,* Westw. Pallidè fusco-pubescens; facie albâ (ocellis 0), thorace vittis duabus longitudinalibus in medio, lateribus, et maculâ utrinquè basin versus alarum albis; abdomine piceo, segmento 1mo fulvo-marginato, 2ndo et 4to albo-marginato, 3tio rufo-marginato, reliquis fusco-marginatis; alis basi et ad costam latè infumatis; pedibus testaceis.—Long. corp. lin. 8¾: long. probosc. lin. 15. Exp. alar. lin. 16.

Habitat in Georgiâ Americæ.—In mus. nostr.

Pangonia *maculiventris,* Westw. Nigra; thorace haud vittato; abdomine rufescenti-fusco, serie dorsali macularum rotundarum nigrarum; alarum nervis (præsertim transversis) fusco tinctis; pedibus fuscis; corpore subtùs pallidiùs pubescenti; ocellis 3.—Long. corp. lin. 6½. (proboscide mutilâ). Exp. alar. lin. 14.

Habitat in Novâ Hollandiâ. In mus. nostr.

LXXIII. *Proceedings of Learned Societies.*

ASTRONOMICAL SOCIETY.

1835. Jan. 9th.—THE following communications were made:

I. Mr. Sheepshanks exhibited a small clock, on Fraunhofer's principle, for giving motion to an equatorial, and explained the construction and use of a moveable piece to be applied to the eye-end of the telescope, for the purpose of micrometrical measurements.

Mr. Sheepshanks also exhibited a telescope fitted up as an equal-altitude instrument, similar to that drawn in Plate XIII. of Dr. Pearson's "Introduction to Practical Astronomy," except that it has straight radii at the base instead of a claw stand. The purport of his remarks was to point out the various objects to which such an instrument might be applied in the hands of a traveller or amateur able and willing to *calculate* his observations. Such an instrument is evidently a tolerable theodolite and level, as well as a very firmly mounted telescope for common purposes, occultations, eclipses, &c.; and if the cross axis be made with care, it would suffice as a transit for the moon and moon-culminating stars in ordinary cases. But it is chiefly valuable as an *equal altitude* instrument, which it is made by an excellent level attached to a small quadrant on one side of the telescope. Further particulars of Mr. Sheepshank's communications on both subjects are given in the Monthly Notices of the Society.

II. Extract of a letter from Sir John Herschel to Francis Baily, Esq., dated Cape of Good Hope, October 22, 1834:

"The climate proves much more favourable for astronomical observation than, during the summer and autumn, I had found reason to expect. Since the setting in of the N.W. winds (in July, August, September, and October, the season being at least a month later this year than usual), the nights have been frequently superbly clear and tranquil, and the definition of stars far beyond anything I ever witnessed at home, allowing the habitual and agreeable use of magnifying powers such as could only be used in the rarest nights in England, and then with difficulty. A brief recapitulation of a few of the more interesting objects and remarks which have fallen under my notice may not be unpleasing to you.

"We landed on the 16th of January; and on the 22nd of February, the 20-feet telescope being erected and the mirrors unpacked, I turned it, for the first time, on the southern circumpolar heavens. The novelty and variety of the objects then seen induced me to defer the commencement of regular sweeping till some of the principal among them had been examined,—such as the wonderful nebula about η *Argus*—the Magellanian clouds—the great cluster adjoining the *Nubicula* minor, and that superb one ω *Centauri*, &c.—and till habit had familiarized me with the delusive appearances assumed by objects under the influence of the S.E. winds, &c.

"On the 5th of March my sweeps commenced, and have continued, at the average rate of about 10 sweeps per month (cloudy and moonlight nights being, of course, *noctes non*), in the course of which I have already accumulated a pretty extensive collection both of nebulæ and double stars; though, in close double stars above the 10th magnitude, this hemisphere is decidedly poorer than the northern.

"On the 1st of April I discovered, in R.A. $9^h\ 17^m$, N.P.D. $147°\ 35'$, a beautiful planetary nebula having a perfectly sharp well-defined disc $3''$ or $4''$ in diameter, and of a uniform light. Its appearance is precisely that of a small planet, with a satellite about $1\frac{1}{2}$ diameter from its edge. Mr. Maclear has been obliging enough to determine its place with great exactness by the circle, by several observations, from which it appears to have no planetary motion.

"On the 3rd of April I discovered another fine planetary nebula, having a perfectly sharp disc, without the least haziness, of about $6''$ diameter. The most remarkable feature about this is its evident *blue colour*, which needs not the presence of lamp light, or that of any red star, to be very conspicuous, as it appears when the nebula stands alone in a dark field. This also has since been (at my request) observed with the circle at the Royal Observatory.

"On the 26th of June I observed an extremely remarkable object, of the class of close double stars, centrally involved in a nebulous atmosphere. Its place is in R.A. $13^h\ 47^m\ 30^s \pm$, N.P.D. $129°\ 9' \pm$. The diameter of the nebula is about $2'$, and the stars are equal, each of them 9·10 mag., distance about $1\frac{1}{2}''$ or $2''$. The nebula is nearly uniform, or, at least, very little condensed about the star.

"On the 28th of June I discovered an annular nebula in R.A. $17^{h}\ 10^{m}\ 36^{s}$, N.P.D. 128° 18′ (all the above places are for January, 1830). It is exactly round, and perfectly well-defined, diameter 15″, very faint, like that in *Cygnus*, and situated among an immense crowd of stars.

"On the 2nd of July I was fortunate enough to light on another very delicate and beautiful planetary nebula in R.A. $15^{h}\ 5^{m}\ 15^{s}$, N.P.D. 135° 1′ (1830·0), having a diameter of $1^{s}\!\cdot\!35$ in time, and a perfectly sharp disc, equal to a star of the 8·9 mag. in light. (My assistant, J. Stone, to whom I showed it, said it was like the moon, round and clean, only smaller.)

"Among the more delicate and close double stars I have observed, either with the 20-feet, or the 7-feet equatorial (which I have succeeded in mounting very satisfactorily under a revolving roof of a peculiar and very simple construction, which answers completely,) which I employ on moonlight nights for measuring double stars, and for the purpose of a review of all the stars in the Brisbane Catalogue (of which I procured from Mr. Richardson an index copy in MS.), I may mention the following:

	h m	° ′	Class.	Magnitudes.	
ξ Apparatus	0 25	125 55	II.	(6) (7·8)	
ζ Phœnicis	1 2	145 9	II.	(5) (9)	
χ Eridani	1 49	142 27	III.	(4·5) (14)	A most delicate object.
θ Reticuli	4 16	153 41	II.	(5)	
τ Argus	10 15	145 11	II.	(5) (10)	
β Hydræ	11 44	122 57	I.	(5) (5·6)	
γ Lupi	15 24	130 34	I.	(3) (3)	Exceedingly close.
*γ Coronæ Aust. ..	18 55	127 18	I.	(6) (6)	*I think this has been observed before.
Anonym.	20 37	153 2	I.	(6) (6)	
22 Piscis Aust. ..	22 43	123 46	I.	(5) (8)	

To which I may add also λ *Octantis*, &c. &c.

"With much difficulty, and after almost despairing of arriving at any satisfactory measures, I succeeded in procuring pretty trustworthy angles for γ *Virginis*, about the predicted perihelion. The stars then were materially better defined than in May, June, or July. They agree, within reasonable limits, with the calculated angle.

"α *Crucis*, if Dunlop's measures are correct, is in a state of pretty rapid rotation, having described 7° since 1826. To the list of binary stars I am at length enabled, unhesitatingly, to add ξ *Libræ*, as the following series of angles will abundantly prove:—

1782·36	Pos. =	7° 58′	H. Catal.
1825·49	....	171 54	South.
1830·28	....	181 30	H., junior, Slough.
1834·35	....	189 3	Ditto, Feldhausen.

This last measure was obtained under circumstances much more satisfactory than it is ever possible to obtain in Europe, from the low situation of the star.

Neither can we doubt that 36 *Ophiuchi* is binary. Mayer makes

the two stars exactly on the same meridian, and diff. decl. = 13″. That is,

1780·±	Pos. 360° 0′	Dist.	13″·00
1822·	.. 227 19	....	5″·55
1834·35	.. 223 34	....	4″·80

But, of all the double stars in the heavens, if Dunlop's measures of it are to be depended on, the star 6 (Bode) *Eridani* is, perhaps, the most remarkable. This star has occurred to me both in my 20-feet sweeps and in my equatorial reviews, and has been measured, in both cases, without being aware in the one what star it was—in the other, that it had been previously observed as double. By subsequent comparison, the place identifies it with Dunlop's No. 5 (*Ast. Soc. Mem.* vol. iii., part ii., pp. 267 and 259). His angle is 73° 6′ *nf* by 3 observations, of which he states the particulars, in December 1825, that is to say, 1825·9, Pos. = 16° 54′, in my notation; whereas, by my sweep, with which the equatorial measures agree almost exactly, the position for 1834, October 5, was 121° 30′, giving a rotation of almost 105° in nine years, or averaging 10°·67 per annum, which, if continued, would bring it round in a period of little more than thirty years.

"My mirrors tarnish with extraordinary rapidity. Half-a-dozen nights' sweeping dims their fresh lustre; and three months' work so effectually spoils them, as to render it useless to go on. Happily I had taken the precaution to bring out a complete polishing apparatus with me, and have been perfectly satisfied with the efficacy of it, as you may judge I have reason to be, when I mention powers of 480, 800, and 1200, as giving perfectly round and well-defined discs with an aperture of twelve inches; and, on one occasion, I have carried the magnifying power as far (I believe, for I have no means of measuring it otherwise than by the focal length of the lens,) as 2000, without destroying *useful* vision. With a power 1200, and a reduced equilateral triangular aperture, *a Eridani* was, I think, the most regular, and beautiful object, on the superb night of the 6th instant, I ever beheld. My sweeping-book says of it, 'The disc a perfect circle, and the six rays' (which the equilateral triangle always gives to large stars,) 'extending, like delicate, perfectly straight, white-hot rods, into the field long after the star was withdrawn from it.'"

III. Transits of the Moon with Moon-culminating Stars, observed at Cambridge Observatory in the month of December, 1834.

IV. Observed Transits of the Moon and Moon-culminating Stars, over the meridian of Edinburgh Observatory, in December 1834, by Mr. Henderson.

ZOOLOGICAL SOCIETY.

Feb. 24, 1835.—A paper was read by Mr. Owen, entitled, "Description of a Microscopic *Entozoon* infesting the Muscles of the Human Body." The author observes, that upwards of fifteen different kinds of internal parasites are already known to infest the human body, but none have been found of so minute a size, or existing in such astonishing numbers, as the species about to be described.

The muscles of bodies dissected at Saint Bartholomew's Hospital had been more than once noticed by Mr. Wormald, the Demonstrator of Anatomy at that establishment, to be beset with minute whitish specks; and this appearance having been again remarked in that of an Italian, aged 45, by Mr. Paget, a student of the hospital, who suspected it to be produced by minute *Entozoa*, the suspicion was found to be correct, and Mr. Owen was furnished with portions of the muscles, on which he made the following observations.

With a lens of an inch *focus* the white specks are at once seen to be cysts of an elliptical figure, with the extremities in general attenuated, elongated, and more opake than the body (or intermediate part) of the cyst, which is sufficiently transparent to show that it contains a minute coiled-up worm. On separating the muscular *fasciculi*, the cysts are found to adhere to the surrounding cellular substance by the whole of their external surface, somewhat laxly at the middle dilated part, but more strongly by means of their elongated extremities. When placed on a micrometer, they measure $\frac{1}{50}$th of an inch in their longitudinal and $\frac{1}{100}$th of an inch in their transverse diameter, a few being somewhat larger, and others diminishing in size to about one half of the above dimensions. They are generally placed in single rows, parallel to the muscular fibres, at distances varying from $\frac{1}{2}$ a line to a line apart; but sometimes a larger and a smaller cyst are seen attached together by one of their extremities, and they are occasionally observed slightly overlapping each other.

If a thin portion of muscle be dried and placed in Canada balsam, between a plate of glass and a plate of talc, the cysts become more transparent, and allow of the contained worm being more plainly seen. Under a lens of the *focus* of $\frac{1}{2}$ an inch, the worm appears to occupy a circumscribed space of a less elongated and more regularly elliptical form than the external cyst, as if within a smaller cyst contained in the larger: it does not occupy more than a third part of the inner space. A few of the cysts have been seen to contain two distinct worms; and Mr. Farr, who has paid much attention to the subject, exhibited a drawing of one of the cysts from this subject, containing three distinct worms, all of nearly equal size. Occasionally the tip of one of the extremities of the cyst is observed to be dilated and transparent, as though a portion of the larger cyst were about to be separated by a process of gemmation; and these small attached cysts are seen of different sizes, and, as it were, in different stages of growth. This appearance, however, Mr. Owen conceives to be explicable without a reference of a power of independent vitality to either of the adherent cysts. The cysts are composed of condensed and compacted *lamellæ* of cellular tissue; but a few are hardened by the deposition of some earthy salt, so as to resist the knife and to produce a gritty sensation when broken under pressure.

When removed from the interior of the cyst, which, on account of the minuteness of the object, is a matter of some difficulty, the worm is usually found to be disposed in two or two-and-a-half spiral coils. When straightened it measures from $\frac{1}{25}$th to $\frac{1}{30}$th of an inch in length, and from $\frac{1}{700}$th to $\frac{1}{800}$th of an inch in diameter: a high magnifying

power is consequently required for its examination. It is round and filiform, terminating obtusely at both extremities, which are of unequal sizes, and tapering towards one end for about a fifth part of its length, but continuing of uniform diameter from that point to the opposite extremity. As it is only at the larger extremity that he has been enabled to distinguish an indication of an orifice, Mr. Owen regards that as the head. He states that this indication has been so constant in a number of individuals examined under every variety of circumstance, that he has no hesitation in ascribing a large transverse linear orifice or mouth to the greater extremity.

The recently extracted worm, observed by means of a Wollaston's doublet, before any evaporation of the surrounding moisture has affected its integument, presents a smooth transparent external skin, inclosing a fine granular and flaky substance or *parenchyma*. It is obvious that the test of coloured food cannot here be applied to elucidate the form of the digestive organs, but there is no appearance of the *parietes* of an alimentary canal floating in a visceral cavity and distinct from the integument of the body, nor was any trace of an orifice observed at the smaller extremity. Mr. Owen was also unable to detect in any instance a projecting *spiculum* or hook at either extremity, or any appearance of the worm having been torn from an attached cyst. Its transparency is such as not to admit of a doubt as to its wanting the ovarian and seminal tubes, and the other characteristics of the complicated structure of *Filaria*, *Ascaris*, and the *Nematoid Entozoa* generally. It is not of a rigid texture, but is extremely fragile, and exhibits when uncoiled a tendency to return in some degree to its former state.

Mr. Owen refers to the genus *Capsularia* as established by Zeder, and rejected by Rudolphi, (who considers its species as belonging either to *Filaria* or *Ascaris*,) for the purpose of contrasting the complicated organization of the worms composing it with the extremely simple structure of the encysted worm under consideration. The circumstance of being inclosed in cysts he stated to be common to many very differently organized genera of *Entozoa*. There are few, indeed, with the exception of those which live upon the mucous surfaces of the body, that do not, by exciting the adhesive inflammation, become inclosed within an adventitious cyst of condensed cellular substance. He regards the simple type of structure exhibited by the minute animal now for the first time described as approximating it to the lower organized groups of the *Vers Parenchymateux* of Cuvier; and both from its locality and from the constancy of its cysts, he regards it as manifesting a relation of analogy to the order *Cystica* of Rudolphi. From all the genera of that order, however, it differs in the want of the complex armature of the head, and of the dilated vesicle of the tail. At first sight it seems indicative of an annectant group which would complete the circular arrangement of the *Entozoa* by combining the form of the *Filariæ* of the first, with some of the characteristics of the *Cysticerci* of the last, of Rudolphi's orders. Unfortunately the class *Entozoa*, as it now stands, is so constituted that an animal may be referred to

it without much real or available knowledge of its organization being thereby afforded: it embraces animals with the molecular, and others with the filiform, condition of the nervous system; conditions which are accompanied by different types of the digestive system, and which indicate not merely differences of class, but even of primary division, in the animal kingdom. Mr. Owen considers the animal under consideration as being most nearly allied to that form of the *Polygastric Infusoria* which is exhibited by the lower organized *Vibriones* of Müller, and of which Ehrenberg has composed his genera *Vibrio, Spirillum,* and *Bacterium*; and that, like the seminal *Cercariæ*, it may be regarded as an example from the lowest class of the animal kingdom having its *habitat* in the interior of living animal bodies. Referring it, however, provisionally, to the class *Entozoa,* in which it would indicate a new order, its generic character may be thus given:

TRICHINA.

Animal pellucidum, filiforme, teres, posticè attenuatum: ore lineari, ano discreto nullo, tubo intestinali genitalibusque inconspicuis. (In vesicâ externâ cellulosâ, elasticâ, plerumque solitarium.)

TRICHINA SPIRALIS. *Trich. minutissima, spiraliter, rarò flexuosè, incurva; capite obtuso, collo nullo, caudâ attenuatâ obtusâ.* (*Vesicâ externâ ellipticâ, extremitatibus plerumque attenuatis elongatis.*)

Hab. in *hominis* musculis (præter involuntarios) per totum corpus diffusa, creberrima.

Mr. Owen further states that within about a fortnight of the former case, a second body similarly affected had been brought into the dissecting-room of Saint Bartholomew's Hospital; and some notes were furnished by Mr. Paget, who first observed the worms in the Italian, with regard to the cases of the two patients while living in the Hospital. From these it appeared that both had died after long and debilitating illness, producing great emaciation, unaccompanied, however, with any eruption on the skin, or any greater loss of muscular power than would probably have arisen from the diseases of which they died. The occurrence of two cases in the same dissecting-room within so short a period of each other, and the recollection of similar appearances being not unfrequently present in other bodies dissected there, combined with an account published in the Medical Gazette for February 2, 1833, of very small *Cysticerci* occurring in the muscles of a subject at Guy's Hospital, which cannot but be considered referrible to the same cause, render it highly probable that a sufficient number of observations will soon occur to elucidate this curious disease. In two of the cases the emaciation was accompanied by external, and in the third by internal, ulceration; but no connexion was traced between the worm and any of the symptoms of the disease.

In a portion of muscle placed, after it had reached a state of incipient putrescence, in spirit of wine for three days, the worms, when pressed out from their cysts, exhibited languid, but sufficiently evident motions, consisting in the tightening and relaxation of their coils: and more languid motions were afterwards noticed in some specimens that were examined a fortnight after the death of the subject from which they were obtained.

Mr. Owen enters at some length into the question of the origin of the cyst, and after comparing its structure and connexions with various more or less analogous productions, he states his opinion that the cyst is adventitious, foreign to the *Entozoon*, and composed of the cellular substance of the body infested, morbidly altered by the irritation of the worm.

The reading of the paper was accompanied by the exhibition of drawings showing portions of the infested muscle, with magnified representations of the cysts and of the worms contained within them; and specimens of the objects themselves were also placed upon the table for examination with the aid of Mr. Pritchard's microscope, lent by him for that purpose.

Mr. Owen also read a Paper "On the Anatomy of *Linguatula Tænioides*, Cuv." After referring to the observations on the anatomical structure of this highly organized *Entozoon*, published by Cuvier and Rudolphi, he proceeds to state the results of his own dissection of a fine specimen, 3½ inches in length, for which he was indebted to Mr. Langstaff. The whole body is invested with a smooth, transparent, rather fine cuticle, which, from maceration, and probably slight decomposition, had become detached. In this *epidermis* there exist no marks of an annulate structure; but the *cutis*, or muscular *parietes* of the body, is distinctly divided into segments slightly overlapping each other, and most obvious on the sides of the body, which are its thickest and most muscular portions. The dorsal and ventral *parietes*, on the contrary, are so transparent as to allow of the contained parts being readily seen through them.

The most essential difference between *Linguatula* and the *Cestoidea*, among which it was first placed by Chabert, consists in the generative organs being androgynous, with the oviduct continued from one end of the body to the other. Rudolphi, uncertain with regard to the structure of the digestive organs, placed it among the *Trematoda;* but the specimen under examination affords conclusive evidence of the justice of Cuvier's removal of it to the *Nematoidea*. The alimentary canal commences at the central *foramen*, or true mouth, and runs straight to the opposite extremity of the body, terminating immediately above the orifice of the genital tube; the *œsophagus* being ⅓rd of a line in length, and opening into a suddenly dilated canal, which continues with little variation of diameter to the *anus*.

At the distance of a line posterior to the mouth, on the ventral aspect of the body, the narrow extremities of two elongated vesicles, 3 lines in length and more than ½ a line in diameter, adhere firmly to the integument, the remainder hanging freely in the abdominal cavity. These Mr. Owen considers to be analogous to the impregnating glands of the hermaphrodite *Rotifera*, &c. The ovary, which is distinct from the tube so called by Cuvier and Rudolphi, is a narrow, elongated, minutely granulated body, extending along the mesial line of the dorsal *parietes* of the body for the extent of its two anterior thirds: about ½ an inch from the head it gives off two slender capillary tubes, which unite below the origins of the lateral nerves, and enter the commencement of the oviduct. The commencement of this tube, formed by the junction of the two ducts

just mentioned with those of the seminal vesicles, is very narrow: in the greater part of its course it is coiled in numerous and complex gyrations around the intestine, but towards the lower third of the body its coils become fewer and more distant, the brown *ova* are seen in scattered masses, and at length it runs parallel with the intestine straight to the *anus*. It is widest at the commencement of the coils; then becomes narrower; and afterwards continues of the same diameter to its termination.

The cerebral *ganglion* mentioned by Cuvier was very conspicuous in the specimen here described: it is situated between the mouth and the commencement of the oviduct, and is consequently sub-œsophageal. Eight pairs of nerves may be distinguished going from it in a radiated manner. This radiated disposition of the nervous system is similar to that which obtains in the *Slug* (*Limax*); and it may also be observed that the disposition of the muscular system in *Limax* is analogous to that of *Linguatula*, being most developed at the sides of the foot, and least along the middle line, which is thin and semi-transparent when viewed against the light. If it were allowable to trace further the analogy of form subsisting between genera so widely separated, the two *fossæ* with their little hooks on either side the mouth of *Linguatula*, might be compared with the two depressions, which, when the *tentacula* are retracted, may be seen in the same situation in the head of the *Slug*. It is the superior organization of these parts, required for its superior powers of locomotion, that renders necessary the further development of the nervous system in the *Slug*; and the completion of the cerebral ring and the development of the supra-œsophageal *ganglia* constitute the chief difference between it and *Linguatula* in this part of their organization. In like manner the action of the muscles in the *Slug* occasions waste, and demands a proportionate supply of new material; and hence the necessity of the superaddition of a sanguineous system for the carriage of the restorative molecules, of a more complex digestive apparatus for their supply, and of respiratory and secretory organs for the elimination of the waste parts of the body. In *Linguatula*, on the contrary, the sphere of action being limited to a dark cavity, the necessity for the superadded structures does not exist; its food, already animalized, requires only a simple canal to complete its assimilation; neither heart nor vessels are conspicuous; and it is probable that nutrition is effected by transudation and imbibition.

The reading of Mr. Owen's Paper was accompanied by the exhibition of drawings in illustration of the structures described in it,

March 10th.—Mr. Owen commenced the reading of a Paper "On the comparative Osteology of the *Orang* and *Chimpanzee*." He stated that he was indebted to Mr. Walker for the opportunity of examining and describing in detail the skeleton of an adult *Chimpanzee*, obtained by that gentleman a few years since from the west coast of Africa, which had enabled him to compare it with that of the young animal. This comparison evidenced in that species a series of changes in the advance towards maturity, analogous to those which take place in the *Orang* and the *Pongo*, and consequently afforded a strong

confirmation of the opinion which regards the latter animal as the adult of the former.

The general appearance and proportion of the *Chimpanzee*, Mr. Owen remarks, are unquestionably the most anthropoid that the *Quadrumanous* order presents; but many marked and essential differences are observable upon a close comparison. The skull of the adult is of a narrow elongated ovate figure, slightly contracting towards the anterior part, which is, as it were, truncated, from the depth and direction of the *symphysis* of the lower jaw. Compared with the rest of the body it is of small size, owing to the arrested development of the cerebral portion, which, as in other *Quadrumana*, is altogether posterior, the face sloping forwards in the adult animal, at an open angle, as in the *Baboons*. Its exterior surface is devoid of the intermuscular frontal and sagittal crests which give so strong a carnivorous character to the skull of the *Orang*. The extent of the origin of the temporal muscles is, however, readily traceable by a slightly elevated ridge of bone: it differs considerably in the adult and in the fœtal skulls, but exactly accords with the increase in the power of mastication required for the due action of the large permanent teeth. It is possible that the slight development of the intermuscular crest may be a sexual character; for in an adult female *cranium* of the *Orang*, the crest was scarcely more prominent than in the *Chimpanzee*: in the latter, however, its development is less to be expected, in consequence of the smaller comparative size of the canine teeth. The muscular impressions on the occipital region are also less strongly marked than in the *Orang*, in which the occipital *foramen* is nearer the posterior plane and its position is more oblique. There is a greater proportion of brain behind the *meatus auditorius externus* in the *Chimpanzee* than in the *Orang*, and this disproportion is much greater in the adult than in the young. Considerable changes also take place in the relations of the *meatus auditorius* with the glenoid cavity for the articulation of the lower jaw, in consequence of the increased development of the maxillary apparatus, while the *cranium* remains nearly stationary; and a process, of which the rudiment is perceptible in the young animal, coextending in downward growth with the changed position of the articulation, becomes interposed between the condyle and the *meatus*, and affords a support against backward dislocation. In the *cranium* of the negro, a similar process may be traced in a rudimental condition, anterior to the *fissura Glaseri*, as in the young *Chimpanzee*.

The *zygoma* is proportionally weaker than in the *Orang*. But the most remarkable characteristic of the skull of the *Chimpanzee*, both in the young and adult states, is the large projecting supraorbital ridges, which being continued into each other across the *glabella*, form a sort of barrier between the head and face. The cranial sutures, which are obliterated in the adult *Orang*, *syndactylous Ape*, and more or less in the *Baboons*, are for the most part persistent in the *Chimpanzee*, as in the human subject. Enough of the squamous suture remains to show that the anterior angle of the

temporal bone joins the frontal, and separates the parietal and sphenoid bones, as in the young. The condyloid processes are proportionately smaller than in the human subject, and their articular surface is directed more outwardly. The *foramen magnum* is thrown back to about the middle of the posterior third of the base of the skull, and its plane is inclined from before upwards at an angle of 5°. There are no posterior condyloid *foramina*. The styloid process is represented by a very small tuberosity. A considerable space intervenes between the *foramen magnum* and the bony palate, which itself equally exceeds the corresponding portion of the human skull. The zygomatic arches are opposite to the middle third of the *cranium* as seen from below, in which position also the contraction of the skull between the *zygomata* offers a marked distinction from that of *Man*.

In the front view of the *cranium*, the threatening supraciliary ridges almost hide the cephalic cavity from view; and the latter, instead of forming a broad back-ground to the face, as in the young *Chimpanzee*, and still more in *Man*, is surpassed in breadth by the lateral boundaries of the orbits and the zygomatic arches. The orbits are seated higher than in the *Orang*, and are larger in proportion; but their plane is more perpendicular, and they are wider apart. In neither the *Chimpanzee* nor the *Orang* is there a supraorbitary *foramen*, but its place is marked by a slight groove. The lachrymal bones are entirely confined to the orbit. A character by which the *Chimpanzee* approximates more closely than the *Orang* to the human subject is found in the nasal bone, which projects in a slightly arched form beyond the interorbital plane, and exhibits at its lower margin a trace of its original separation into two lateral portions: it is anchylosed with the *os frontis* and the suture obliterated. The malar bones are largely developed, and two or three small *foramina* are observable in the process on the outside of the orbit. The contour of the upper jaw from the nasal aperture to the incisor teeth is almost straight, while in the *Orang* it is rendered concave by the greater development of the alveolar processes of the intermaxillary bones. The obliteration of the sutures between these bones and the upper maxillary takes place at a much earlier period in the *Chimpanzee* than in the *Orang*; although in the young animal, when the first dentition is complete, traces of the original separation are still visible. The situation of the *foramina incisiva* is always indicative of the original extent of these bones, and in no *Mammal* do they approximate so closely to the incisive teeth as in *Man*. The infraorbitary canal opens upon the face by a single *foramen*: Mr. Owen has observed a second in one young specimen, but never more. In the *Orang* there are usually three or more, as in many of the inferior *Simiæ*. The lower jaw, like the upper, is characterized by its strength and relative size. Its *symphysis* recedes, but the depth at this part is much less than in the *Orang*. The *alveoli* advance more nearly to the level of the condyle, and consequently approximate proportionally to the structure of the brute; the mental *foramen* is single.

Mr. Owen next proceeds to notice the dental *formula* and the

characters of the teeth; and observes particularly on the modifications in their arrangement and relative position consequent on the preponderating development of the *cuspidatus*. He also points out the more important deviations which occur in the disposition and development of the different bones of the face in connexion with the same influential condition of the organs of mastication; and then continues his description of the skeleton of the *Chimpanzee* by passing to that of the trunk.

The number of the *vertebræ* is the same as in *Man*; but an additional rib subtracts one from the lumbar to be added to the dorsal series. The spines of the cervical *vertebræ* are simple and elongated; that of the third being the shortest, with the exception of the *atlas*, which, as usual, is without spine. The bodies of the lumbar *vertebræ* are proportionally smaller than in *Man*; a difference easily accounted for by the necessity of affording a basis for the support of the latter in the erect position; and the same recession from the *Bimanous* type is manifested in the narrow and elongated form of the *sacrum*. In the adult animal, but less conspicuously in the young, the iliac bones rise on either side of the last lumbar *vertebra*, and are partially attached to it. The coccygeal are anchylosed together, but not with the *sacrum*; three are distinctly visible in the young. Of the sacral *vertebræ* only the two superior are united to the iliac bones. The *pelvis* differs from that of *Man* in all those particulars which characterize the *Quadrumana*, and which relate to the imperfection of their means of maintaining the erect position. The iliac bones are long, flat, and narrow, the anterior surface stretching outwards almost parallel with the plane of the *sacrum*; the aperture is elongated and narrow; and the tuberosities of the *ischia* are broad, thick, and curved outwards. There is, however, a provision for a more extended attachment of the *glutæi* muscles in a greater breadth of the *ilia* between the superior spinous processes than is observed in the inferior *Simiæ*; and we may thence infer that the semi-erect position is more easily maintained in the *Chimpanzee*.

In the relative size and strength of the lower extremities, the *Chimpanzee* claims a much closer relationship to the human subject than the *Orang*. Both animals exhibit in this respect permanent conditions that are transitory in *Man*: in the *Orang* the legs have the curtailed proportions which they present in the human *fœtus* of four months' gestation; in the *Chimpanzee* they retain the relative size of the yearling infant. The *femur*, not more bent anteriorly than in *Man*, has its neck of equal comparative length, but standing out more obliquely from the shaft. In the adult as well as in the young *Chimpanzee*, the depression in the head of the *femur* for the attachment of the *ligamentum teres*, which is wanting in the *Orang* and the *Pongo*, is found to exist, notwithstanding the remark of Meckel to the contrary. The *tibia* and *fibula* are proportionally thicker and stronger than in *Man*; and the *patella* proportionally smaller. In their relative size and position the tarsal bones more closely resemble the corresponding bones of the human subject than those of any other

Quadrumanous animal. The outer articulating surface of the *astragalus* is, however, of larger size, and a corresponding disproportion exists between the external and internal *malleolus*, the latter, from its smaller size, presenting less resistance to the rotation of the *tarsus* inwards. The *os calcis* projects further backwards than in the lower *Simiæ*, but is more compressed laterally, and of much smaller proportional size than in *Man*. The *os naviculare* projects further downwards, and the internal cuneiform bone has a corresponding inclination below the level of the tarsal bones. But whilst the *Chimpanzee* exhibits the *Quadrumanous* characters in these particulars, and especially in the curtailed proportion and detached opposable condition of the *hallux*, it approaches more nearly to *Man* in the length and strength of that member. The whole foot is much longer than in the human subject; and the entire organization of the inferior members evidently bespeaks a creature destined to reside in forests, the modifications of the bony structure which add to the facility of climbing and grasping, rendering the entire frame more dependent on the upper extremities for the means of progression and support.

The size and expansion of the *thorax* is a marked character in the *Chimpanzee*: it has thirteen ribs on each side, and the last two pairs are proportionally longer than in *Man*, the end of the last not being pointed, but widened for the attachment of a cartilage. The *sternum* is flattened, but not so broad as in the *Orang*. The *harmonia* between its body and the *manubrium*, and those between the four single pieces of which the body is itself composed, remain visible in the adult skeleton. The clavicle is long and strong, and is not straight, as in the *Orang*, but sigmoidally curved, though in a less degree than in *Man*; while the *scapula*, on the other hand, recedes further from the human type than in the *Orang*. The *humerus* very closely resembles that of the human subject, but is proportionally longer and stronger, and has its twist more strongly marked and lower down on the bone. As the segments of the limbs recede further from the trunk they become subject to greater and more varied modifications. Thus the disproportionate length of the *humerus* is succeded by a still greater elongation of the fore-arm, the bones of which are also more curved from each other than in *Man*, and the inter-osseous space consequently enlarged. The bones of the *carpus* are the same in number as in the human subject; but the *trapezium* and *trapezoides* are proportionally smaller, while the *os pisiforme* nearly equals the *os magnum*. The thumb does not quite equal in length the metacarpal bone of the first finger, and is as slender and weak as it is short. Some little disproportion also exists between the relative lengths of the fingers; but taken together they are relatively stronger and more elongated than in *Man*.

After completing his detailed examination of the skeleton, Mr. Owen reverts to the changes which it undergoes in its progress to maturity, especially as regards the proportions of the head and face; and states that he has derived full confirmation of the identity of species in the young and adult *crania*, from a comparison of the crowns of the permanent teeth lodged within the jaws of the young

Chimpanzee with those which had replaced the deciduous teeth in the older specimen. The resemblance in point of size and figure was exact, and left no room for doubt as to the point in question. The succession takes place precisely as in the human subject, but the permanent teeth, and especially the incisors and canines, are proportionally longer. The particulars of their form and arrangement are given at length.

This portion of the paper was accompanied by an extensive series of admeasurements of the different parts of the skeleton in the adult and young *Chimpanzee*, compared with those of the young and adult *Orang*; and was further illustrated by numerous drawings, and by the exhibition of Mr. Walker's skeleton of the *Chimpanzee*, lent by him for the purpose.

The second portion of the paper commences with the remark that the opportunity which the rare and interesting skeleton of the adult *Chimpanzee*, in the possession of Mr. Walker, had afforded of tracing the changes of structure occurring in that *Ape*, in its progress to the adult condition, had induced the author to review the question relative to the identity of the young *Simia Satyrus* with the great *Pongo* of Borneo, formerly brought by him under the notice of the Society (Phil. Mag. and Annals, N.S., vol. ix. p. 60,) and to consider the osteological structure of the latter, or adult *Orang*, with reference to that of its less powerful and more anthropoid congener, the *Chimpanzee*. This comparison would show that the number and value of the points of resemblance, or of approximation, to the *Bimanous* structure are in favour of the *Chimpanzee*; although in this, as in most other instances, there are some particulars of its organization indicative of a more marked relation with the inferior forms of the group than with those which rank immediately below it*.

In common with the skull of the *Mandrill* that of the adult *Orang* is remarkable for its flattened *occiput*, formidable canine teeth, huge jaws, widely expanded zygomatic arches, and strongly developed cranial ridges; but it exhibits a marked distinction in its less brutalized expression, resulting from the more perpendicular slope of the face, the absence of the projecting supraciliary ridges, the greater expansion of the cerebral cavity, and the non-development of the supramaxillary ridges. Its *cranium* is less flattened at the *vertex* than that of the *Chimpanzee*; and but little exceeds in capacity that of the young at the period of acquiring its first permanent *molares*, the increase in size being chiefly dependent on the thickening of the walls of the skull. The ridges which circumscribe on the frontal bone the origin of the temporal muscles inclose a triangular space, the smoothness of which strongly contrasts with the irregular surface of the remainder of the *cranium*; and the interparietal crest rises, as in the *Hyæna* and other *Carnivora*, high above the general level. The situation of these ridges, with reference to the sutures, is only determinable by comparing the faint commencement of their growth in the young animal, very few traces of the sutures remaining in the

* Do not these facts indicate the existence of a tendency towards a circular succession of affinities in the group formed by the *Simiæ*?—E. W. B.

adult skull. That between the *ala* of the sphenoid bone and the descending angle of the parietal, by means of which the frontal and temporal are kept separate, and which offers one of the few osteological differences in which the *Orang* has a closer approximation to the human structure than the *Chimpanzee*, is among those which continue to be marked even in the adult. The occipital *foramen* approaches in figure, position, and aspect, nearer to that of the lower *Mammalia*; the occipital condyles are more closely approximated anteriorly; the anterior condyloid *foramina* are double on each side; and the carotid *foramen* is situated more posteriorly, and is relatively smaller, than in the *Chimpanzee*. The petrous portion of the temporal bone is smaller, while the glenoid cavity forms a much larger proportion of the base of the skull. This cavity, if such it may be called, presents a quadrate, almost flattened surface, slightly concave in the transverse, and slightly convex in the antero-posterior direction, affording an interesting correspondence with the structure of the molar teeth, and indicative of the vegetable diet of the animal. The styloid and styliform processes are wanting, as in the *Chimpanzee*; the mastoid is represented by a protuberant ridge, and its cellular structure is visible in consequence of the thinness of the external table. The ant-auditory process is more developed than in the *Chimpanzee*, and the margins of the auditory *foramina* are smoother.

On the bony palate, the relative positions of the *foramina incisiva* correspond with the increased development of the laniary teeth, and consequently deviate in a proportionate degree from their positions in the *Chimpanzee* and in the human subject. Two or three *foramina* remain on either side and indicate the original separation of the incisive bones; and similar indications of the original *harmoniæ* between the incisive and maxillary bones are seen on the anterior part of the skull. In the *Chimpanzee* the obliteration of these sutures takes place some time before the temporary teeth are shed; in the *Orang* they remain until the permanent teeth are almost fully developed: in the human subject the intermaxillary bones can be traced as distinct elements only in the early periods of fœtal existence, when they were first detected by the poet Gœthe. In the *Orang* no part of the *os nasi* projects, as in the *Chimpanzee*, beyond the plane of the nasal processes of the superior maxillary bones; and there are no traces of its original separation at the mesial line, while in the *Chimpanzee* such traces are usually found, and Dr. Traill observed two distinct *ossa nasi* in the young of that species dissected by him. The lachrymal bones are proportionally larger than in *Man*; but, as in the *Chimpanzee* and the higher *Quadrumana*, they are confined to the orbit, the whole outer boundary of which has a more anterior aspect than in the *Chimpanzee*, and is relatively broader and stronger, but with the oblique posterior edge less developed. The interorbital space is relatively narrower, the disproportion increasing with the development of the superior maxillary bones, and evidencing a still further departure from the human form. There are three infra-orbital *foramina* instead of one; the upper maxillary bones are much

more largely developed in consequence of the great size of the laniary teeth; and the incisor teeth project more obliquely forwards than in the *Chimpanzee*.

"In all the peculiarities," Mr. Owen observes, "of the *Orang's* skull, which are independent of the changes consequent on the second dentition, we find an exact correspondence between the *Simia Satyrus*, or young animal, and the *Pongo*, or adult. The *crania* equally exhibit the absence of the projecting supraciliary ridges; the presence of the double anterior condyloid *foramina*; the numerous infra-orbitary *foramina*, and those in the malar bone; the same disposition of the cranial sutures; the same form of the *os nasi*; and contraction of the inter-orbital space. The character of the lower jaw by which it differs from the *Chimpanzee*, viz. the greater height and breadth of the *rami*, and the greater depth of the *symphysis*, are equally manifested in the young as in the old *Simia Satyrus*. In following out the same observations with regard to the germs of the permanent teeth in the young *Orang*, the same satisfactory results are obtained in reference to their identity with those which are fully developed in the old animals, as were previously detailed in the account of the *Chimpanzee*."

Mr. Owen then proceeds to describe in detail the appearances presented by the germs of the permanent teeth, and to compare them with the adult; and concludes this part of his subject by some observations on the apparent confusion in which these germs lie hidden within the jaw, and on the admirable and orderly arrangement by which the most perfect regularity is established in their ultimate position. Applying these observations to the replacement of the teeth in man, he inquires, how it happens that when the chances of disarrangement are so much fewer, the mal-position of the permanent teeth is of so frequent occurrence, and finds the solution of this problem in a mischievous interference with the agents to which the necessary changes have been entrusted. "The means by which the growth of the permanent teeth are kept in due restraint are too often prematurely removed by anticipating the natural period of the extraction of the temporary teeth; the act of extraction accelerates the growth of the concealed teeth, both by the removal of the check which nature has imposed upon it, and by the irritation induced in the surrounding parts; and their full development being consequently acquired before the jaws have been sufficiently enlarged, they occupy more or less of the relative position which they had when half formed within their bony cavities."

The conditions of the superior development of the spinous processes of the cervical *vertebræ* in the *Orang*, are obviously the backward position of the occipital *foramen*, the disproportionate development of the face, and the general anterior inclination of the *vertebræ* themselves. Those of the sixth and seventh *vertebræ* have a slight inclination towards the head, indicating that the centre of motion in this region is nearer the head than in *Man*. The whole of the cervical region is proportionally shorter, and consequently better adapted to support the head; and the entire vertebral column has one gene-

ral curve dorsad from the *atlas* to the commencement of the *sacrum*, where there is a slight curve in the contrary direction. As in *Man*, the number of the dorsal or costal *vertebræ* is twelve, and this constitutes one of the more important differences between the *Orang* and the *Chimpanzee*. That of the lumbar *vertebræ* is four, as in the *Chimpanzee*, in the skeleton of the *Pongo* preserved in the Museum of Comparative Anatomy at the Garden of Plants, and in the trunk of the skeleton of the adult *Orang* in the collection of the Society; in which latter, as the bones remain connected by their natural ligaments, there is no room for supposing a *vertebra* to have been accidentally lost. The additional lumbar *vertebra* in the skeleton of the *Pongo* in the College of Surgeons, on which some stress has been laid, as indicative of its specific difference from the young *Orang*, which has uniformly presented but four, indicates its abnormal character by its form and situation. The human subject occasionally presents a similar *lusus* in the addition of a sixth lumbar *vertebra*. The spines of these *vertebræ* are much shorter than in the *Chimpanzee*: as in the latter, the *sacrum* is longer, narrower and straighter than that of *Man*. Five sacral *vertebræ* are perforated for the passage of the spinal cord; three are imperforated, and are consequently coccygeal: the latter are anchylosed together, but not with the *sacrum*, in the adult.

The *ilia* are as much expanded as in the *Chimpanzee*, but flatter; and the *ischia* are less extended outwards, corresponding with the smaller development of the lower extremities. Both the *ischia* and *ossa pubis* resemble those of the *Chimpanzee*, in their more elongated form; and the whole *pelvis* equally deviates from the *Bimanous* type in its position with regard to the trunk. The form of its superior aperture is an almost perfect oval, the antero-posterior diameter of which is to the transverse as three to two; and the axis of the brim forms, with that of the outlet, a much more open angle than in the human subject. The chest is amply developed, equalling in size that of the human subject, except in being somewhat narrower from side to side. The ribs are narrower and less flattened, but their curvature is nearly the same as in *Man*; the twelfth is much longer, and has a long cartilage at its free extremity. The *sternum* is short, but broader than in the *Chimpanzee*: it is composed, below the *manubrium*, of a double series of small bones, seven or eight in number. This composition, always seen in the young *Orang*, is sufficiently obvious in the adult *Pongo* in the Museum of the College of Surgeons, but much less so in that of the Garden of Plants at Paris. In the young *Chimpanzee* the *sternum* is composed of a single series of bones; while in the human subject, although at an early period of ossification, a single series only of ossific centres appears: at a later stage the lower part of the *sternum* is frequently seen to be composed of a double series.

The clavicles are almost straight; and the *scapula* also differs from that of the *Chimpanzee* in its greater breadth, and from that of *Man* in the inclination of its spine towards the superior *costa*, in the acro-

mion being narrow and claviform, and in the absence of the flattened and over-hanging margin of the spine. Other differences exist in the comparative dimensions and features of the supra- and sub-spinal *fossæ*, in the inclination of the coracoid process, and in the direction of the glenoid cavity. But the principal feature in the organization of the *Orang*, and that in which it differs most from the *Chimpanzee*, consists in the relative length of the upper and lower extremities, the arms in the former reaching to the heel. The articular surface of the head of the *humerus* forms a complete hemisphere; and in some specimens that bone is perforated between the condyles. The principal peculiarities in the fore-arm consist in the large space between the *radius* and *ulna*, occasioned by the outward curve of the former, and in the absence of the acute margin on its ulnar aspect. The proportion borne by the *radius* to the *ulna* is in *Man* as 11 to 12; in the *Orang* as 36 to 37. The bones of the hand offer the same elongated form, with the exception of those of the thumb, which does not reach to the end of the metacarpal bone of the fore-finger. Those of the *carpus* have their ossification completed at a later period than in *Man*, and allow a freer motion upon each other: the *os pisiforme* is divided into two. Of the fingers, the proximal *phalanges* are more curved than in *Man*, and the distal more pointed, not expanding to afford support for an extended surface of delicate touch.

As the upper extremity of the *Orang* exceeds in length that of the *Chimpanzee*, so the lower differs as much in the contrary respect; preserving throughout life much less than the fœtal proportions of the human subject. The *femur* has a straight shaft, no depression on the head, a shorter neck forming a more obtuse angle with the shaft, and no *linea aspera* posteriorly. The inner condyle not being produced beyond the outer, the axis of the *femur* is in the same line with that of the *tibia*, as in the *Chimpanzee*. The inward curve of the *tibia* occasions a much larger space between it and the *fibula* than in *Man* or in the *Chimpanzee*. The *patella* is smaller in proportion than in *Man*, of an oval shape, and with a single articulating surface. The bones of the *tarsus* are numerically the same with those of the *Chimpanzee*, and have the same general form, but admit of freer motion on each other. A greater degree of obliquity in the articulating surface of the *astragalus* causes the whole foot to be turned more inwards; and the *os calcis* has still less projection backwards than the *Chimpanzee*. The internal cuneiform bone recedes most from the human type in having a greater development towards the tibial aspect, and in having the surface of articulation for the *hallux* below the range of the other metatarsal bones, all of which are much longer and more bent and have greater interspaces than the human. That of the *hallux* extends very little beyond the middle of that of the second toe, and stands off from it at an acute angle. The peculiarity of the structure of the *hallux* first noticed by Camper, in seven out of eight *Orangs* observed by him, viz. its possessing no ungueal *phalanx* and consequently no nail, loses much of its im-

portance as a specific character from the fact that the individual dissected at the Society's Museum a few years since had very perfect, but small, black nails, and two *phalanges*, and that the same number of *phalanges* exist in the natural skeleton of Lord Amherst's *Orang* in the Museum of the College of Surgeons. The *phalanges* of the other toes are remarkably elongated, and those of the first series are curved. The middle toe is longer than the rest, while in the *Chimpanzee* it barely surpasses the second. The concavity of the great toe is turned more towards the other toes than in the *Chimpanzee*, (in which that toe is also longer, having always two *phalanges* in addition to the metatarsal bone,) is set more forwards on the internal cuneiform bone, and has its concavity directed more towards the sole of the foot. The resemblance to the human foot is consequently greater in the *Chimpanzee* than in the *Orang*.

In conclusion Mr. Owen adverted to a fine specimen of the skull of a *Pongo* in the possession of Mr. Cross, of the Surrey Zoological Gardens, which presents the following differences when compared with the skull of the *Pongo* in the Museum of the College of Surgeons.

It is shorter in the antero-posterior diameter, and rises higher at the *vertex*. The supraorbitary ridges are more prominent; the plane of the orbits is more vertical, and their lateral exceeds their perpendicular diameter. The profile line of the skull is concave between the *glabella* and incisor teeth, while, in the specimen in the Museum of the College, it is almost a straight line between the same parts. The *symphysis* of the jaw from the interspace of the mesial incisors to the origin of the *genio-hyoidei* muscles, measures $2\frac{1}{2}$ inches in Mr. Cross's specimen, but equals $3\frac{3}{4}$ inches in the *Pongo* in the College Museum. There is also a remarkable difference in the position of the zygomatic suture. In the *Pongo* of the College Museum it commences at the distance of a quarter of an inch from the orbital process of the malar bone, and extends obliquely backwards to within $1\frac{1}{4}$ inch of the origin of the zygomatic process of the temporal bone. In Mr. Cross's specimen the same suture commences 8 lines from the orbital process of the malar bone, and extends to within 10 lines of the origin of the temporal zygomatic process, so that it is much nearer the middle of the *zygoma*.

With these differences, however, there exist the same form and proportions of the teeth, and the same peculiarities of the *foramina* and sutures which distinguish the *Orang* from the *Chimpanzee*. So that although the difference in the shape and general contour of the two skulls, is greater than is usually observable in those of other wild animals, yet Mr. Owen does not consider them sufficient to afford grounds for a distinction of species. He thinks it, however, probable that they may be indicative of varieties of the *Orang* inhabiting distinct localities, and remarks that it would be interesting with that view to compare the *crania* of ascertained specimens from Borneo and Sumatra, to which Islands this very remarkable species appears to be confined.

Meteorological Observations made by Mr. THOMPSON *at the Garden of the Horticultural Society at Chiswick, near London, and by Mr.* VEALL, *at Boston.*

Days of Month. 1835.	Barometer. London. Max.	Barometer. London. Min.	Barometer. Boston. $8\frac{1}{2}$ A.M.	Thermometer. London. Max.	Thermometer. London. Min.	Thermometer. Bost. $8\frac{1}{2}$ A.M.	Wind. Lond.	Wind. Bost.	Rain. Lond.	Rain. Bost.
April 1	30·029	29·959	29·40	70	39	57	sw.	calm	...	0·04
2	29·836	29·755	29·30	73	50	56	s.	calm	...	...
3	29·936	29·803	29·30	68	44	52	sw.	calm	...	·30
4	30·184	30·115	29·60	64	43	45·5	E.	calm	0·04	·15
5	30·364	30·235	29·77	59	39	44	NE.	NE.	·02	·03
☽ 6	30·414	30·383	29·80	60	41	51	sw.	calm	...	...
7	30·431	30·367	29·83	68	33	51	w.	NW.	...	...
8	30·351	30·281	29·69	69	45	55	w.	calm	...	...
9	30·217	30·138	29·47	63	52	53	w.	w.	...	...
10	30·308	30·183	29·51	61	38	52	w.	N.	...	...
11	30·389	30·363	29·85	53	27	47	NE.	N.	...	...
12	30·341	30·218	29·75	62	34	52·5	sw.	calm	...	...
○ 13	30·238	30·183	29·63	67	28	49	sw.	calm	...	...
14	30·143	30·037	29·60	66	32	55	sw.	calm	...	...
15	30·116	29·906	29·33	62	32	52·5	N.	calm	...	...
16	30·231	30·195	29·65	50	27	38	N.	N.	·03	...
17	30·229	30·215	29·75	50	29	39	N.	N.	·01	...
18	30·139	30·051	29·55	56	34	46	w.	N.	...	...
☾ 19	30·446	30·326	29·35	58	41	46	N.	calm	...	...
20	30·499	30·493	29·89	60	41	52	NW.	calm	...	...
21	30·475	30·441	29·80	60	37	56	w.	N.	·04	...
22	30·460	30·441	29·86	63	41	53	N.	N.	...	...
23	30·486	30·411	29·82	55	46	52	N.	N.	·01	...
24	30·395	30·255	29·75	60	43	52	N.	calm	...	...
25	30·173	29·859	29·47	56	37	47·5	NW.	N.	...	...
26	29·746	29·672	29·22	52	25	47	NW.	NW.	...	...
● 27	29·686	29·650	29·25	51	27	43	N.	calm	...	·14
28	29·847	29·844	29·40	54	38	47	NE.	NW.	·04	...
29	29·720	29·583	29·40	46	43	50	NE.	E.	·75	...
30	29·616	29·558	29·15	51	43	46	sw.	E.	·12	·43
	30·499	29·558	29·57	73	25	49·5			1·06	1·79

Remarks.

London.—April 1, 3. Fine. 4. Slight rain. 5. Rain: hazy. 6—10. Fine. 11. Fine: frosty at night. 12—15. Fine: cold at night. 16. Clear, cold and dry: hail and sleet in afternoon: frosty at night. 17. Snow showers, with cold north wind. 18. Bright sun: overcast. 19. Fine. 20—23. Overcast and fine. 24. Slight haze. 25. Cloudy. 26, 27. Cold and dry: sharp frost at night. 28. Fine. 29, 30. Cold rain. In this month vegetation has been much checked by frosty nights. Most injury was sustained on the night of the 16th, after showers of sleet, which drenched the blossoms with moisture; and in the morning their cups were filled with icicles.

Boston.—April 1. Fine: rain early A.M. 2. Fine: 3 P.M. thermometer 67°: rain with thunder and lightning P.M. 3. Rain. 4. Cloudy. 5. Rain. 6. Cloudy. 7, 8. Fine. 9. Cloudy. 10—12. Fine. 13—15. Cloudy. 16. Fine: ice this morning: snow P.M. 17. Fine. 18, 19. Cloudy. 20—22. Fine. 23, 24. Cloudy. 25. Stormy. 26. Fine: hail and rain A.M. and P.M. 27, 28. Fine. 29. Stormy: rain P.M. 30. Stormy.

INDEX TO VOL. VI.

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QC
1
P4
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v.6
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